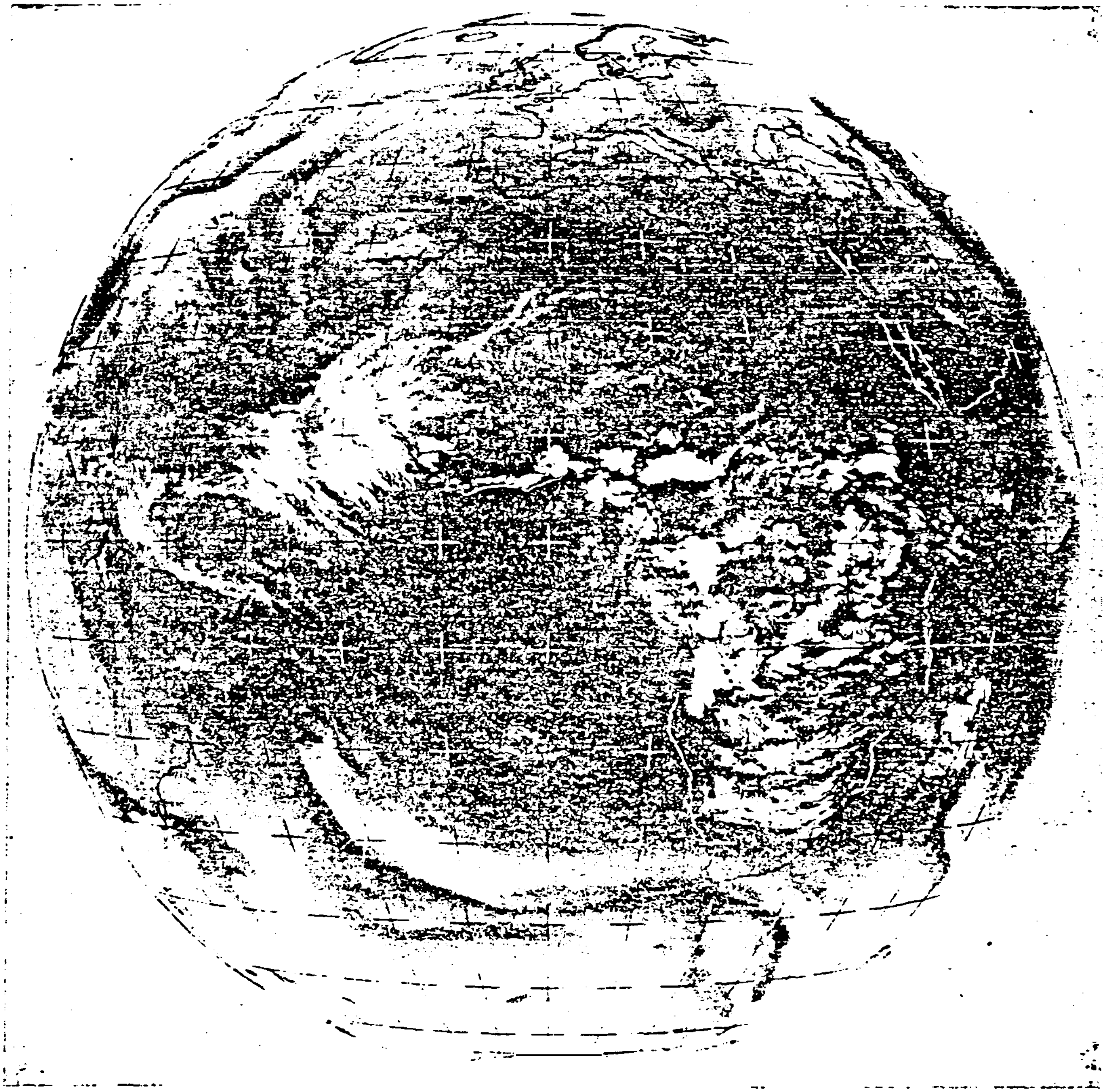
european space agency
agence spatiale européenne
europäische weltraumorganisation

.K.9



METEOSAT
HIGH RESOLUTION IMAGE DISSEMINATION

METEOSAT 'SYSTEM GUIDE - VOLUME 9

METEOSAT HIGH RESOLUTION IMAGE DISSEMINATION

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ISSUE 4

AUGUST, 1984

TABLE FOR NOTING **AMENDMENTS** RECEIVED

Amendment No.	Dated	Inserted in the publication by	date
1	15/12/86		
2			
3			
4			
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METEOSAT HIGH RESOLUTION IMAGE-DISSEMINATION

C O N T E N T S

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INTRODUCTION

This document is intended to provide users planning to receive and exploit METEOSAT High Resolution Disseminations with the technical and operational specifications necessary to design and operate a Primary Data User Station (PDUS). It is assumed that the reader has already studied the document:

"Introduction to the METEOSAT System"

Further information and scheduling notices can be obtained from:

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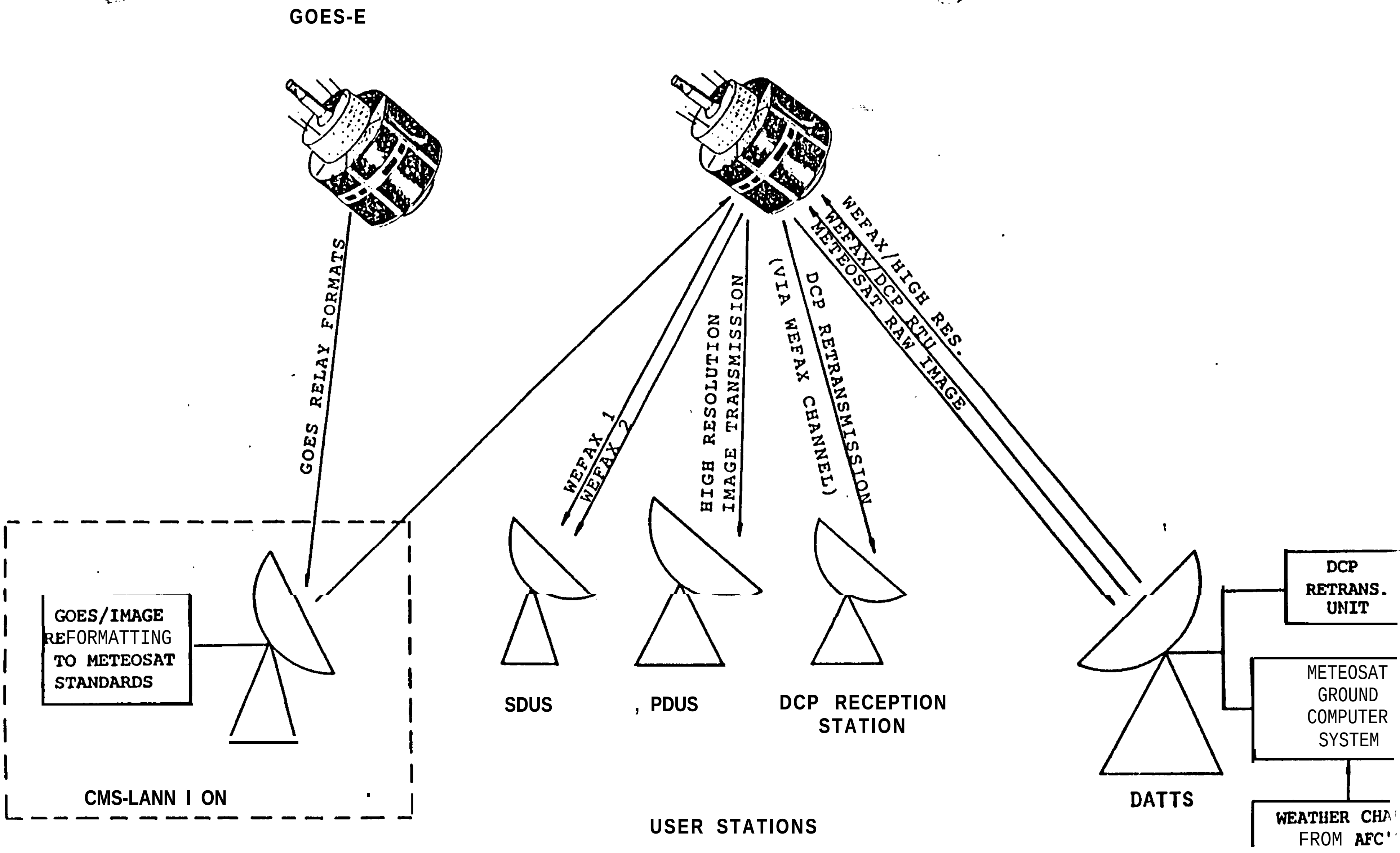
1. DISSEMINATION OF IMAGES

METEOSAT dissemination is the process whereby image data and other meteorological information are relayed via the, spacecraft to the user community.

The spacecraft has two dedicated dissemination channels operating in the S-Band at 1691.0 MHz and 1694.5 MHz, which are both'used to distribute a wide variety of data. Two forms of transmissions are employed: conventional analogue transmissions (WEFAX), and special digital transmissions (HR=High Resolution). The WEFAX transmissions are dedicated to user stations for picture recording and use the APT (Automatic Picture Transmission) format. Information about these METEOSAT transmissions can be obtained from the document "METEOSAT WEFAX Transmissions":

The HR digital data are in a format specific to METEOSAT and are designed for users requiring full resolution data in a form suitable for local computer processing.



FIG, 1 METEOSAT DISSEMINATION MISSION

2. PRIMARY DATA USER STATIONS (PDUS)

METEOSAT High Resolution Transmissions can be received by "Primary Data User Stations (PDUS)" which, at the simplest form, consist of:

- parabolic antenna
- low noise amplifier
- down converter
- receiver with demodulator
- bit- and frame-synchroniser
- image processor

The actual configuration of the PDUS is related to the special requirements of the user. Some of the possible features of a PDUS are:

- high resolution hard copy unit
- colour display
- computer for processing of meteorological data

The images distributed via HR-Dissemination have the full resolution of the raw-image. Therefore the following options could be performed using a PDUS:

- display of images adding false colours or other image enhancements
- computer enlargements of image segments
- production of animation loops generated from METEOSAT image areas

- remapping of images into different projections (e.g., Mercator, Polar Stereographic)

- production of hard copies of the
  - canplete image
  - special areas of the image

- retransmission of special formats via landlines to other stations (e.g. in APT format)

- merging the image data with other inputs, such as
  - radar data
  - conventional meteorological data
  - forecasts or analyses

In addition, certain meteorological products could be derived from the high resolution data such as :

- cloud motion vectors
- sea surface temperatures
- cloud analysis

However, because of the complicity of the processing required (and the high resulting cost) it is not recom- mended to develop such systems but to use the derived meteorological products as produced by the Meteosat Exploitation Project at ESOC, Darmstadt, FRG.

It is impossible to list all options for a PDUS-design and hence also impossible to quote the costs of a total station. These costs are affected strongly by the extent of an image handling system included in the station.

However, several manufacturers produce such stations and information can be obtained directly from them. For a list of manufacturers see document:

> "Manufacturers and Suppliers of METEOSAT User Stations and Data Collection Platforms".

3. IMAGE SOURCES

The images disseminated as high-resolution formats are from two different sources: METEOSAT and GOES-E.

3.1. METEOSAT

METEOSAT takes pictures of three spectral bands:

Visible	(0.4 - 1.1 µm)
Infrared	(10.5 - 12.5 µm)
Water Vapour	(5.7 - 7.1 µm)

The infrared and water vapour images are composed of 2500 pixels and 2500 lines with a spatial resolution of 5 km at the sub-satellite point.

The visible picture contains 5000 pixels and 5000 lines in case both visible channels should be simultaneously used. The resulting resolution is 2.5 km at the sub-satellite point.

Assuming nominal image scanning is performed, every half hour one set of pictures is available. This set could consist of

- either 2.5 km resolution visible and S-km infrared
  or
- 5 km resolution visible, infrared and water vapour

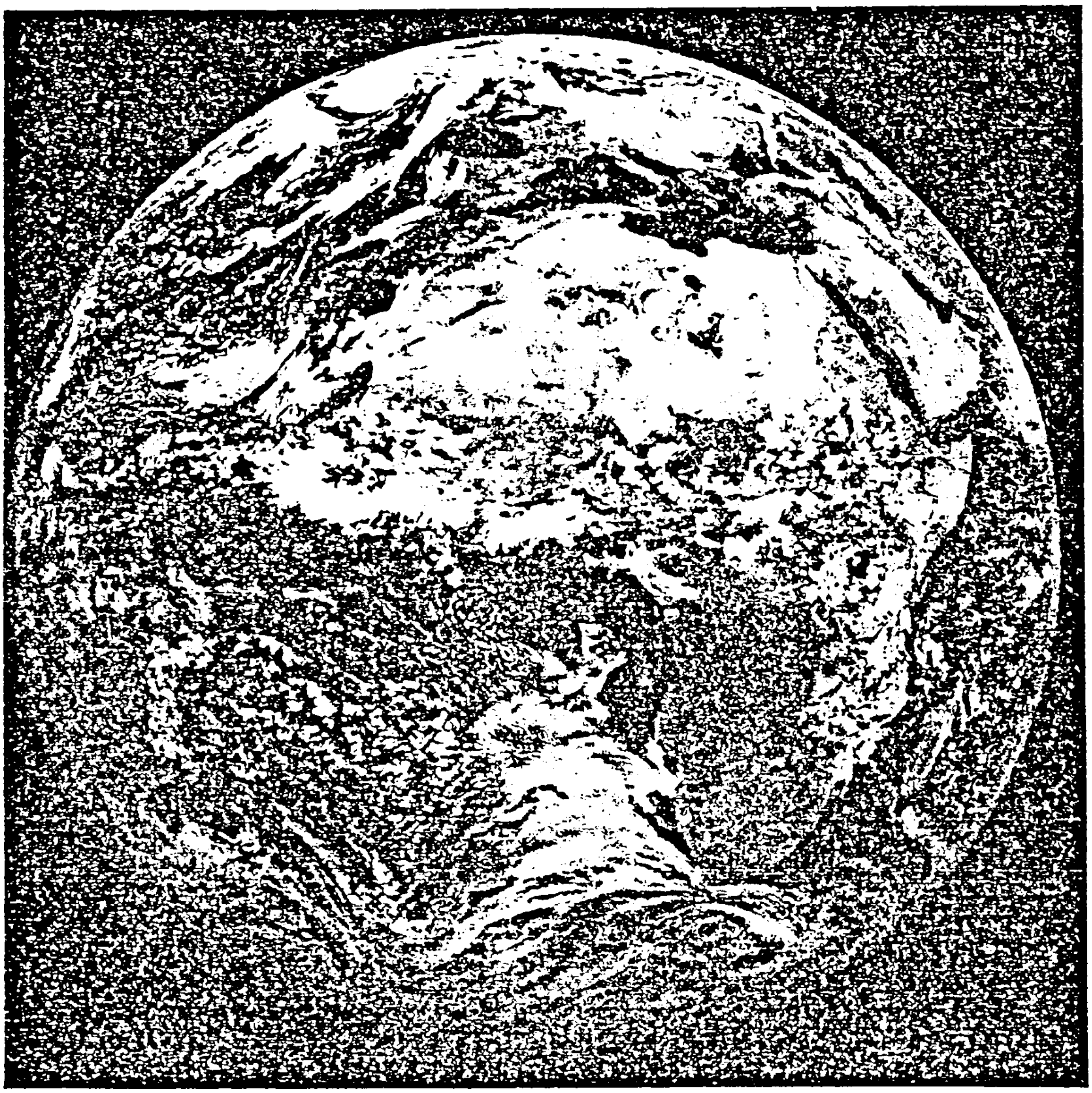


FIGURE 2 Example of METEOSAT-VIS-Image

In this full disk image taken by visible light, clouds appear white and space is seen as black.

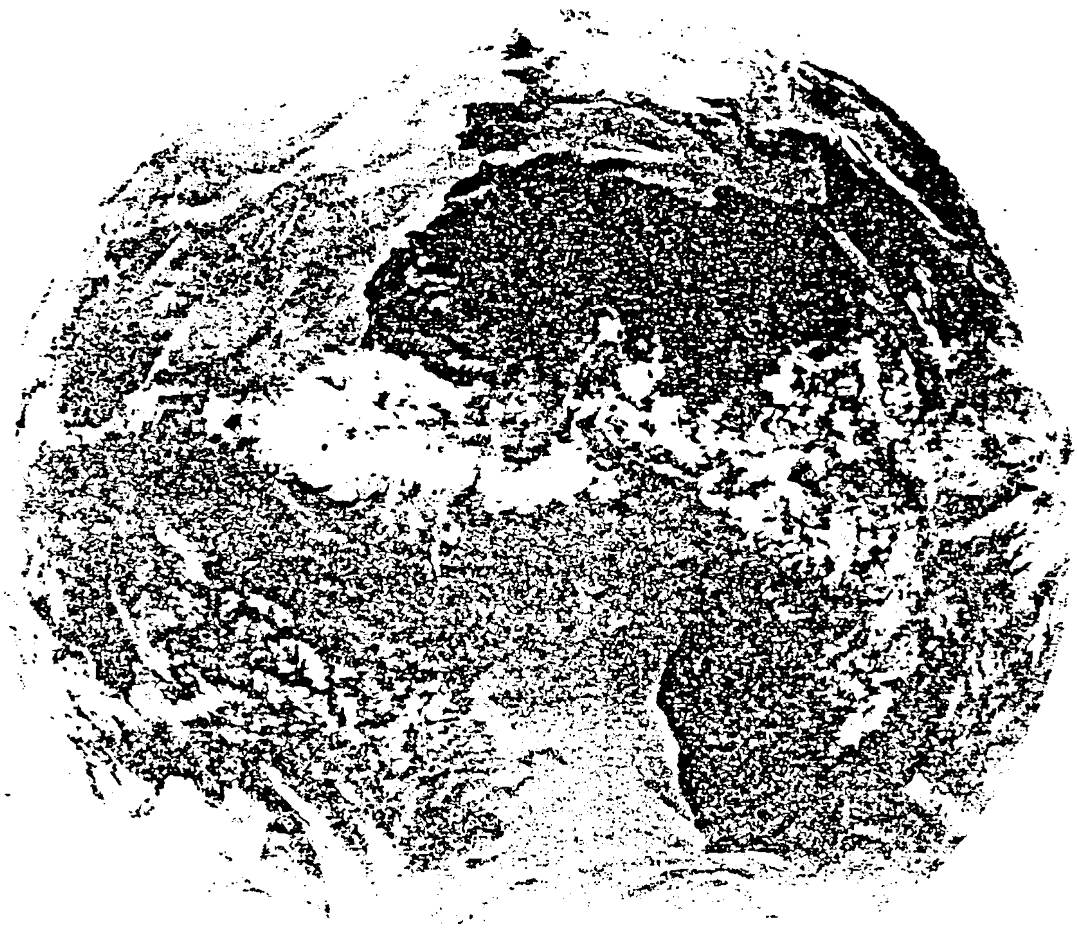


Figure 3 Example of METEOSAT-IR-Image
This image utilises the 11 µm "window" band of infra-red radiation, in which grey scales represent temperature. Space and cold high clouds appear white, warmer (low) clouds grey, and hot deserts as very dark areas.

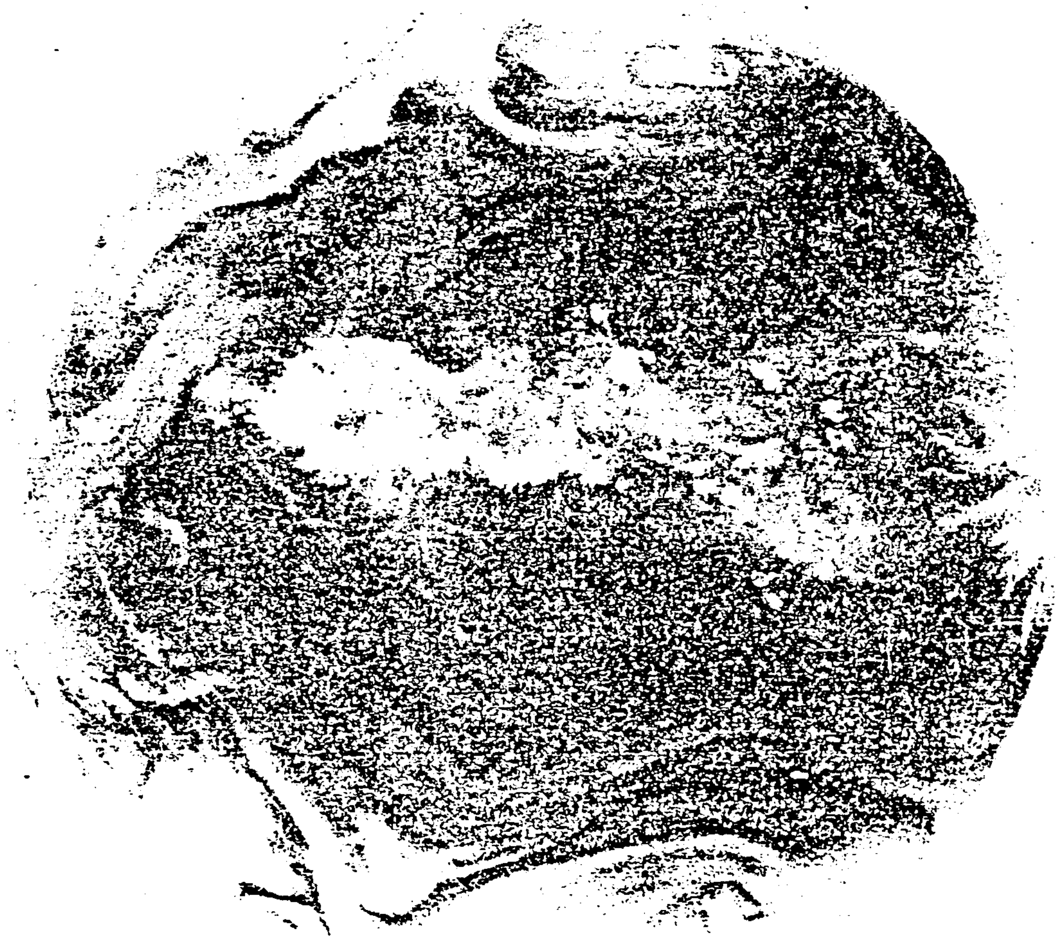


FIGURE 4 Example of METEOSAT-WV-Image
The channel used is the 6 µm water vapour absorption band of infra-red radiation. White areas represent low temperatures, and this can be equated with areas of high humidity. The darker shades indicate a lower level of atmospheric humidity. The image represents the upper atmosphere only and does **not** provide an earth view

Future METEOSAT spacecrafts will be able to deliver **VIS1,** VIS2, IR and WV information simultaneously. The first launch of this type of spacecraft **is** planned for 1987 (MOP 1).

The visible and water vapour images are coded in 64 grey-levels, the infrared image in 256 levels. After pre-processing the 64 grey-levels of the visible and water vapour image are expanded to 256 levels.

Future METEOSAT spacecrafts will deliver all information in 8 bits corresponding to 256 levels.

3.2. GOES-E

The GOES-E satellite located in a geostationary orbit at **75°W** observes in two spectral bands:

visible channel : 0.55 - 0.75 pm
infrared channel : 10.5 - 12.6 µm

In the infrared the "Visible and Infra-Red Spin/Scan Radiometer" **(VISSR)** scans one line on each spin, providing roughly 7 km resolution at the sub-satellite point. In **the visible** the VISSR scans eight parailel lines on each spin designed to provide approximately 1 km resolution at the sub-satellite point. Visible channel scan lines are combined in groups of two, four or eight to provide 2, 4 or 7 km resolution respectively.

A full disc image. consists of 14 000 lines in the visible spectrum and 1750 lines in the infrared spectrum. It is obtained in 17.5 minutes. Full disc pictures are normally scheduled at half hourly intervals, but for special occasions (for example during the hurricane season) the operation is changed to include more frequent scans of smaller areas.

FIGURE 5 Example of GOES-Image

4. HIGH-RESOLUTION FORMATS

METEOSAT High-Resolution Formats are mainly originated from ESOC Darmstadt. Only the relay transmission of the American GOES-E satellite located over Central-America is formatted in the Centre Météorologique Spatiale in Lannion (France). Both Centres transmit the formats in the same mode via satellite. The transmission speed is 166.66 kbit/sec.

4.1 High Resolution Formats originated in ESOC

All raw-image data as received at the ground computing centre from the satellite are normally "pre-processed", i.e., an amplitude processing in such a way is performed that lines still correspond to physical scans. Registration errors caused by the differing fields of view of the sensors are corrected.

The pre-processed image is subject to a geometrical correction in order to canpensate the shift deformation caused by the spacecraft's deviation from its nominal geostationary position. The scanned image is "moved" (rectified) into the reference image frame which corresponds to the image as seen from the nominal. satellite position.

The geometrical image processing is based on an image geometry model which derives its inputs from horizon extraction on the actual infrared image and results in a very accurate fine attitude determination. The rectification of the current image is calculated from the deformation vector field obtained from the image geometry model of the current image. This image geometry model is updated **dynamically** and describes the movement of an image related reference frame as function of radiometer scan step. This allows to calculate the deformation vector for every image point on the earth. All results of the image processing chain are stored in a cyclic file. This file is designed to cover sufficient history (e.g., 100 days) in order to perform long term quality and trend analysis. The described rectification of images allows the uncomplicated production of loop sequences of images.

4.1.1. A-Format

The format A represents the whole earth-disc as seen by METEOSAT's visible, infrared or water vapour sensors. The image information of one, two or three sensors can be transmitted in one format. The following lists the total range of possible combinations.

Format	VIS	IR	WV	Transmission Time (min)
AV	2500 lines VIS1 * 5000 pixels + 2500 lines VIS2 * 5000 pixels or 2 *2500 lines VISx * 5000 pixels			23.5
AI		2500 lines * 2500 pixels	-	6
AW			2500 lines * 2500 pixels	6
AIV	as AV	as AI		29.3
AIW		as AI	as AW	. 11.8
AIVW	2500 lines VIS* * 5000 pixels	a8 AI	a8 AW	23.5
AIVH	2500 lines VISx * 2500 pixels Data reduction by taking only each second pixel within the line	as AI		11.8

* VISx = VIS1 or VIS2 depending on selected sensor channel

With the exception of format **AIVH,** all images have the same resolution as the original **METEOSAT** raw-image. An A-Format consists of 5000 pixels and 5000 lines in the visible spectrum and 2500 pixels and 2500 lines in the infrared and water vapour spectra. The sub-satellite paint resolution therefore is **2.5km** in the visible and 5 km in the infrared and water vapour spectrum. In AIVH formats the visible information is reduced to 2500 pixels and 2500 lines by suppression of every second pixel within an Image line and using the information of one visible channel only.

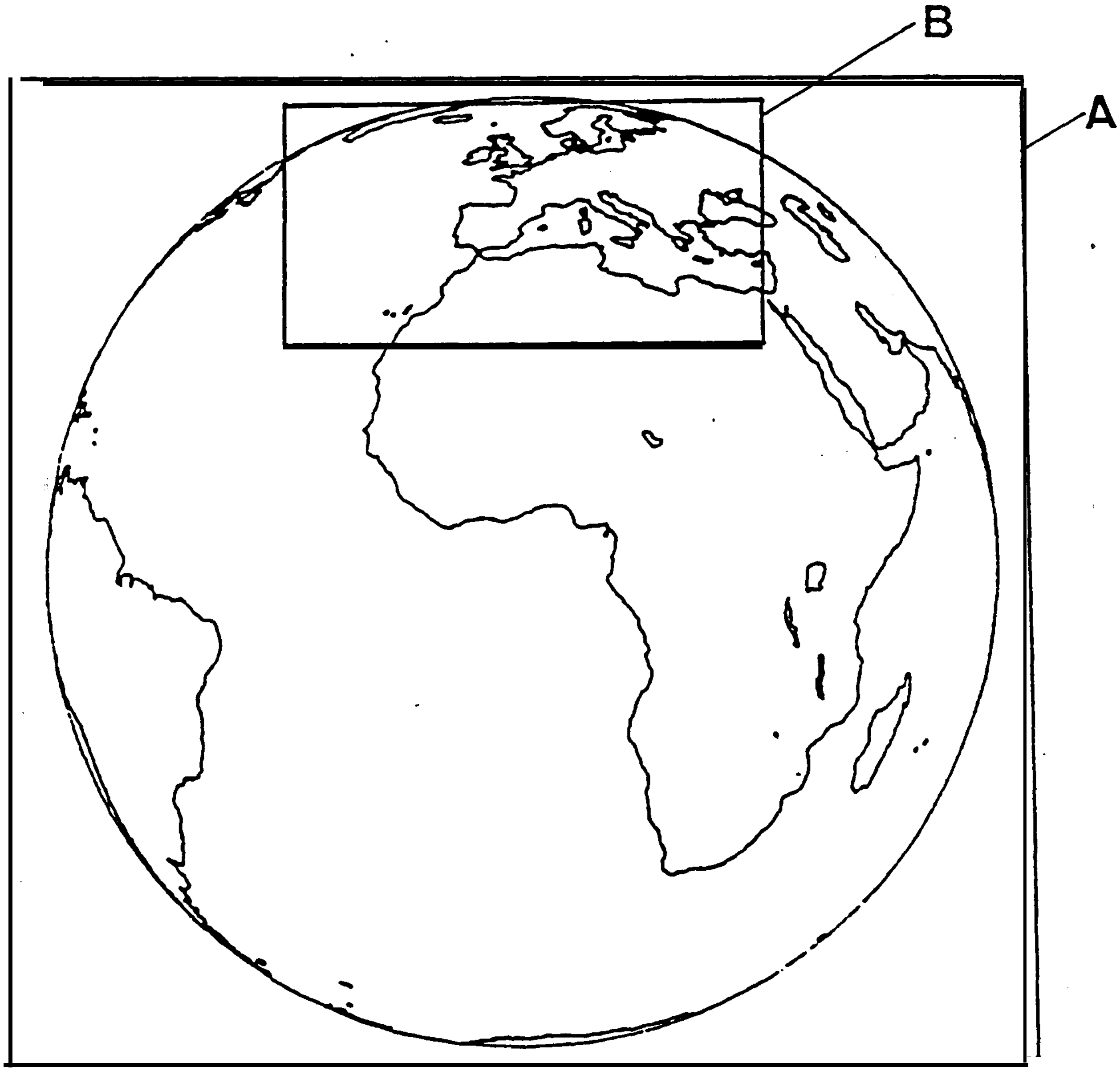


FIGURE 6 High-Resolution Formats A and B disseminated from ESOC, Darmstadt (METEOSAT images)

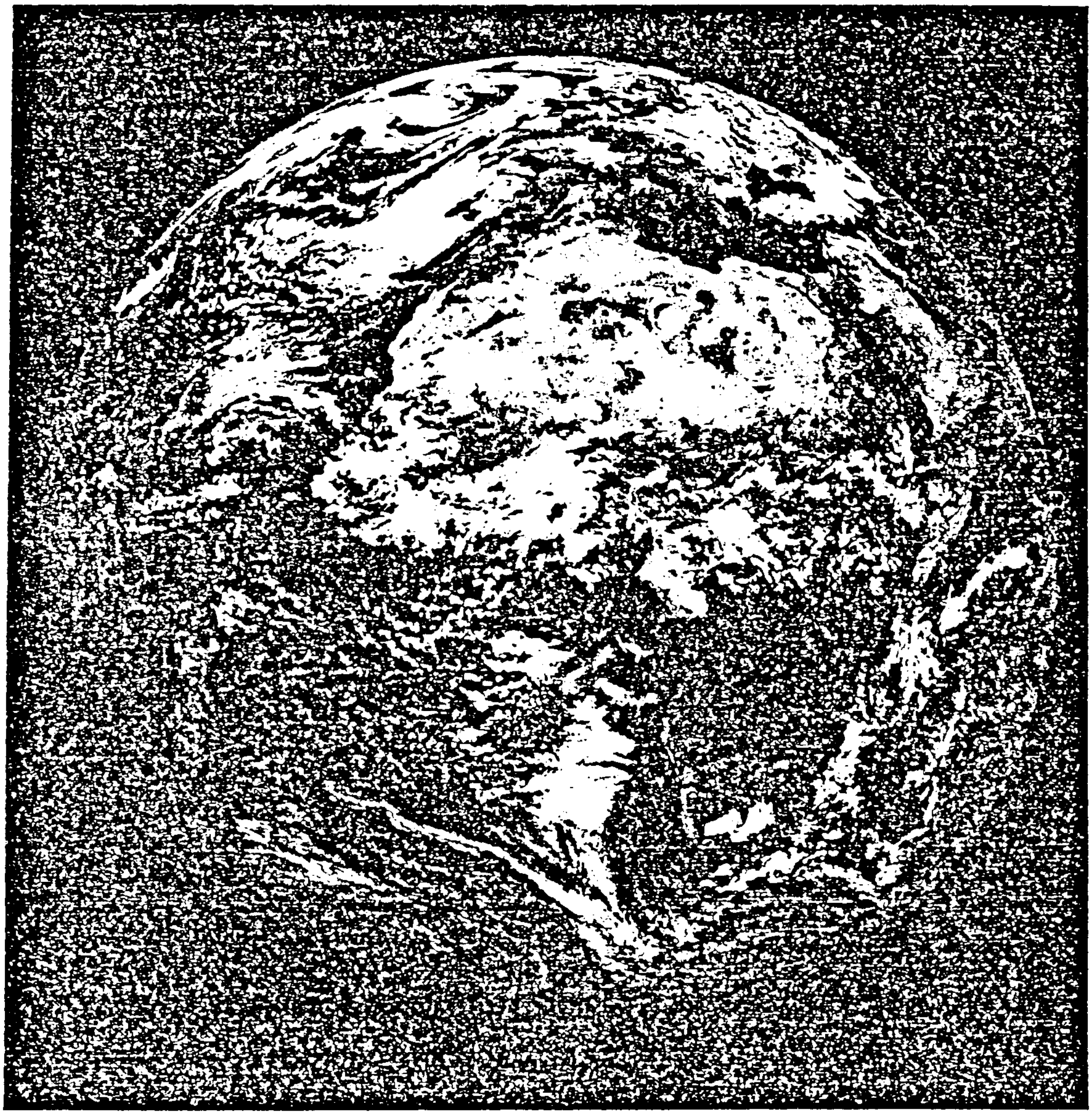


FIGURE 7 Example of A-Format (Visible)

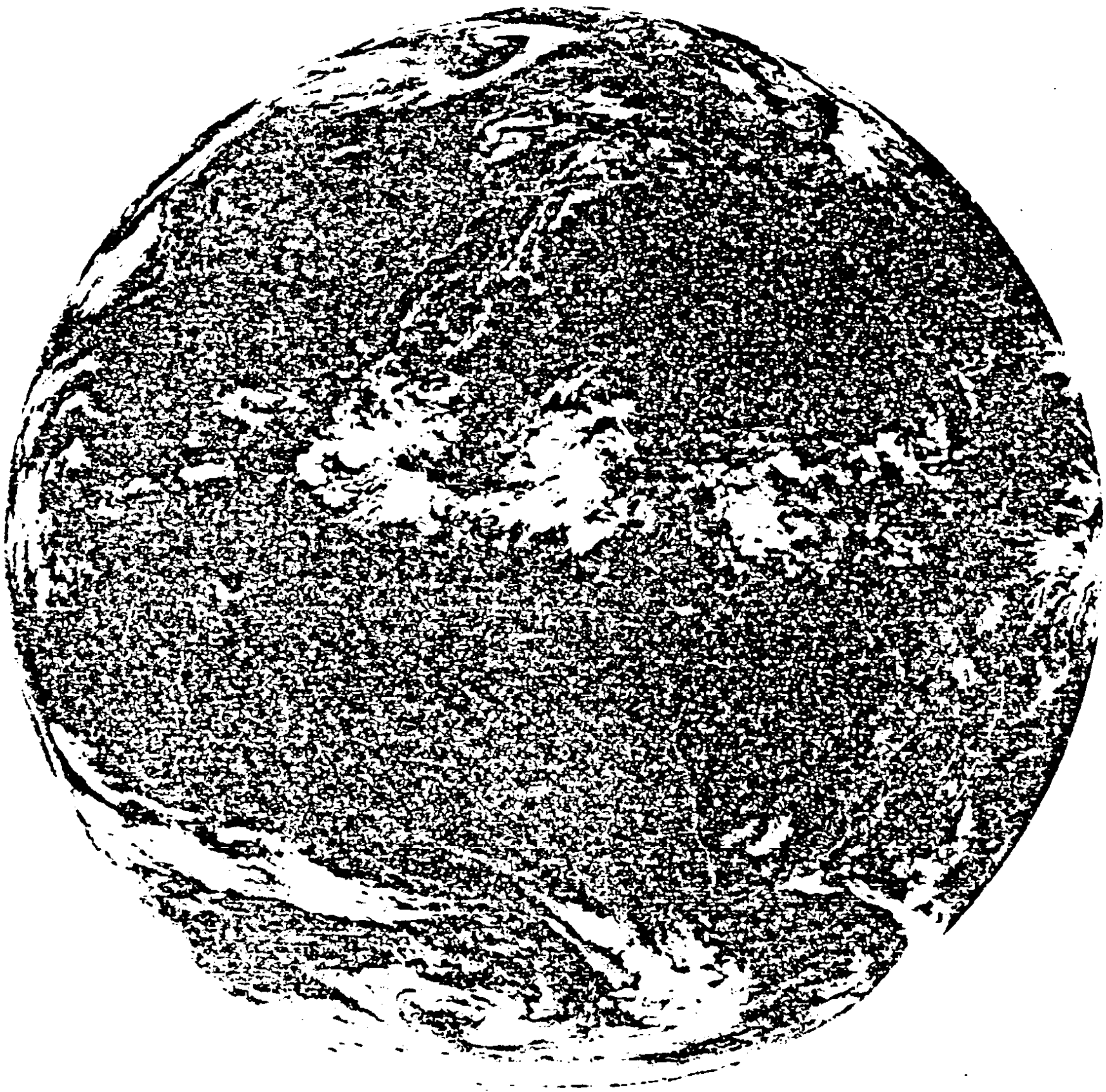


FIGURE 8 Example of A-Format (Infrared)

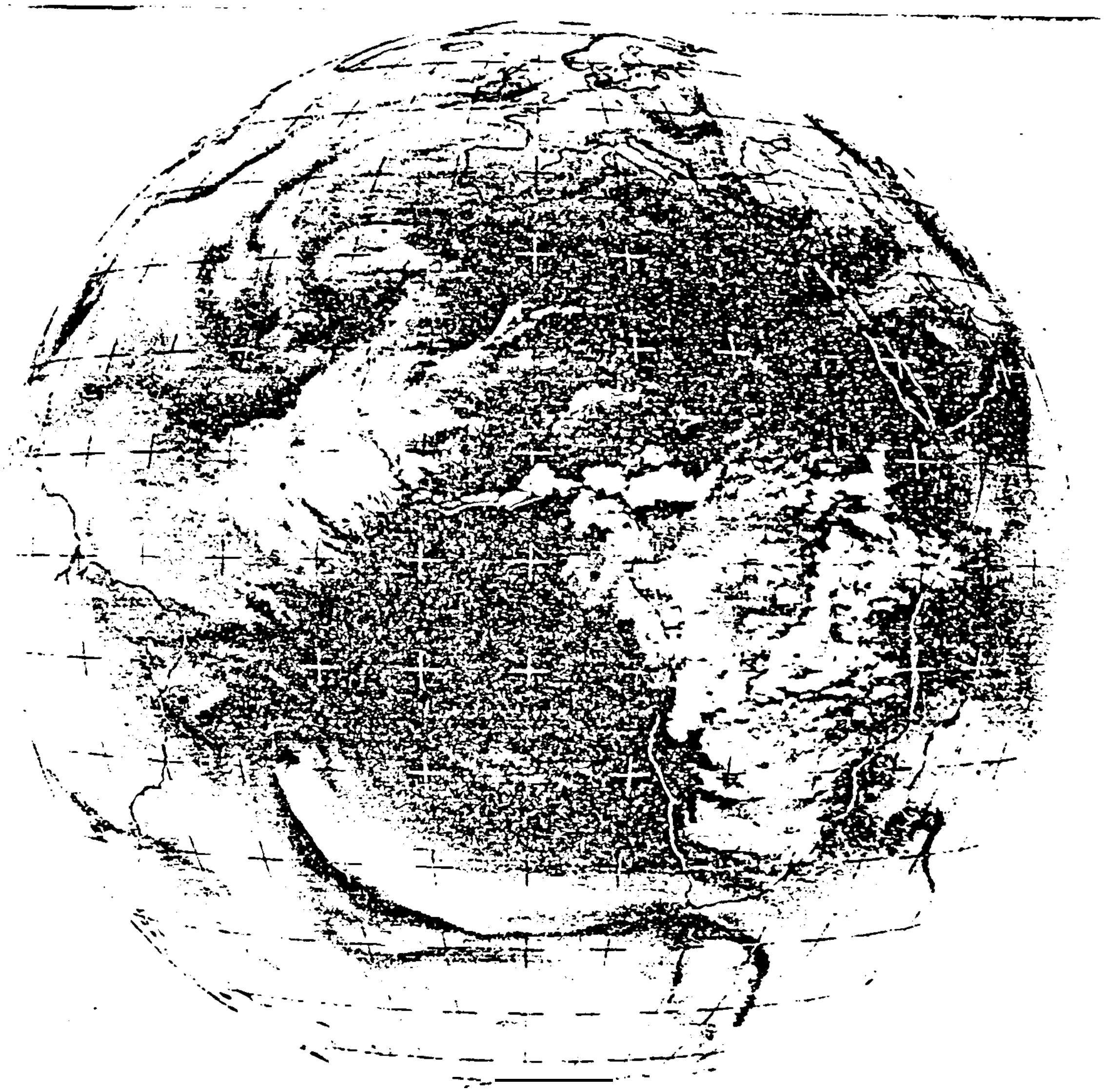


FIGURE 9 Example of A-Format (Water Vapour)

4.1.2. B-Format

Format P represents the European, North-African and Middle-Eastern regions as seen by METEOSAT's visible, infrared and water vapour sensor. The transmission of a B-Format could contain the information of o..e, two or three spectra. The following formats could be produced:

Format	VIS	IR	WV	Tranamlaaion Time (min)
BV	625 lines VIS1 + 625 lines VIS2 * 2500 pixels or 2 * 625 lines VISx * 2500 pixels			3.1
BI		625 lines * 1250 pixels		0.9
BW			625 lines * 1250 pixels	0.9
BIV	as BV	as BI		3.8
BIW		as BI	as BW	1.6
BIVW	625 lines VISx * 2500 pixels	as BI	as BW	3.1

* VISx = VIS1 or VIS2 depending on selected sensor channel

The first line number of B-formats is 1810, the last line 2434, the first pixel within the lines la 626, the last 1875 in case of IR and WV information. The first pixel within VIS lines is either 1252 or 3751.

FIGURE 10 Example of B-Format (Visible)

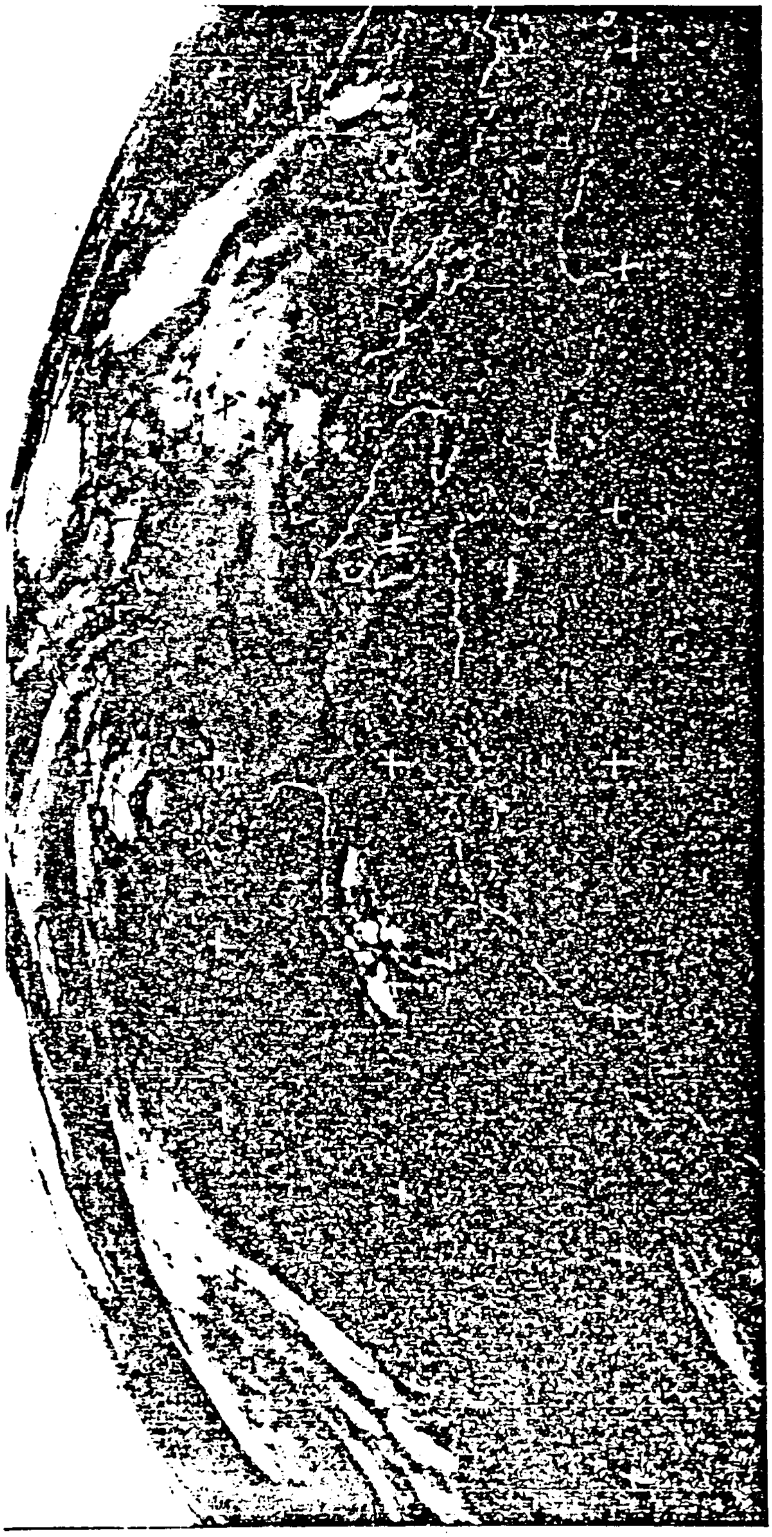


FIGURE 11 Example of B-Format (Infrared)

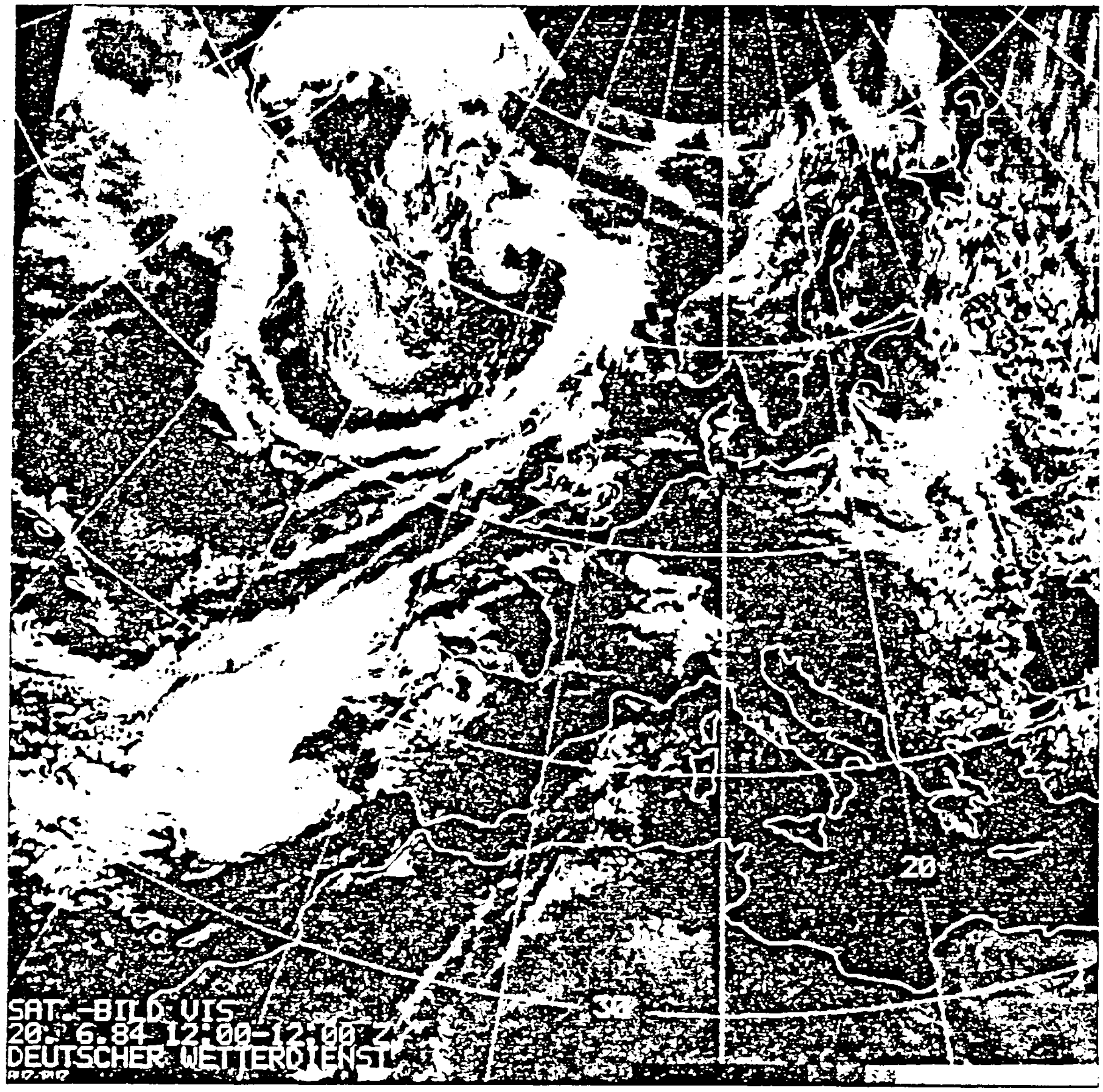


FIGURE 12 Example of a B-Format in polar stereographic projection (visible)

4.2. High-Resolution Formats originated in CMS-Lannion

4.2.1. X-Format

The X-Format represents the North and South American continents as seen by the visible and infrared sensors on board the American GOES-E satellite. Visible and infrared images are transmitted simultaneously. The X-Format consists of 2500 pixels and 2500 lines in the visible and 1250 pixels and 1250 lines in the infrared spectrum. The resolution therefore is 7 km at the sub-satellite point in the infrared and 2 km in the visible band.

The transmission time of the X-Format is 7.4 minutes.

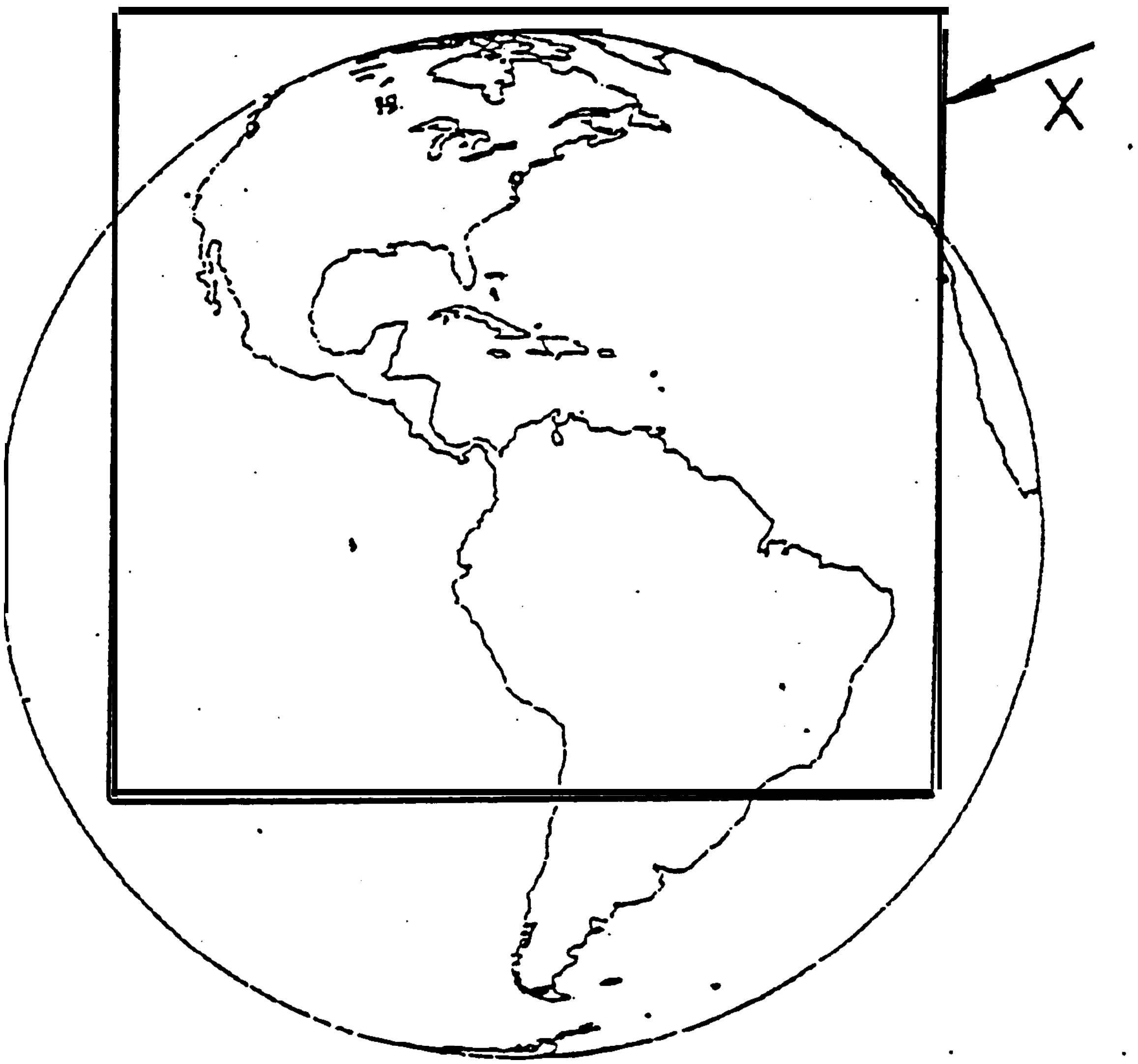


FIGURE 13 High Resolution Format X disseminated from CMS-Lannion (GOES-E image)

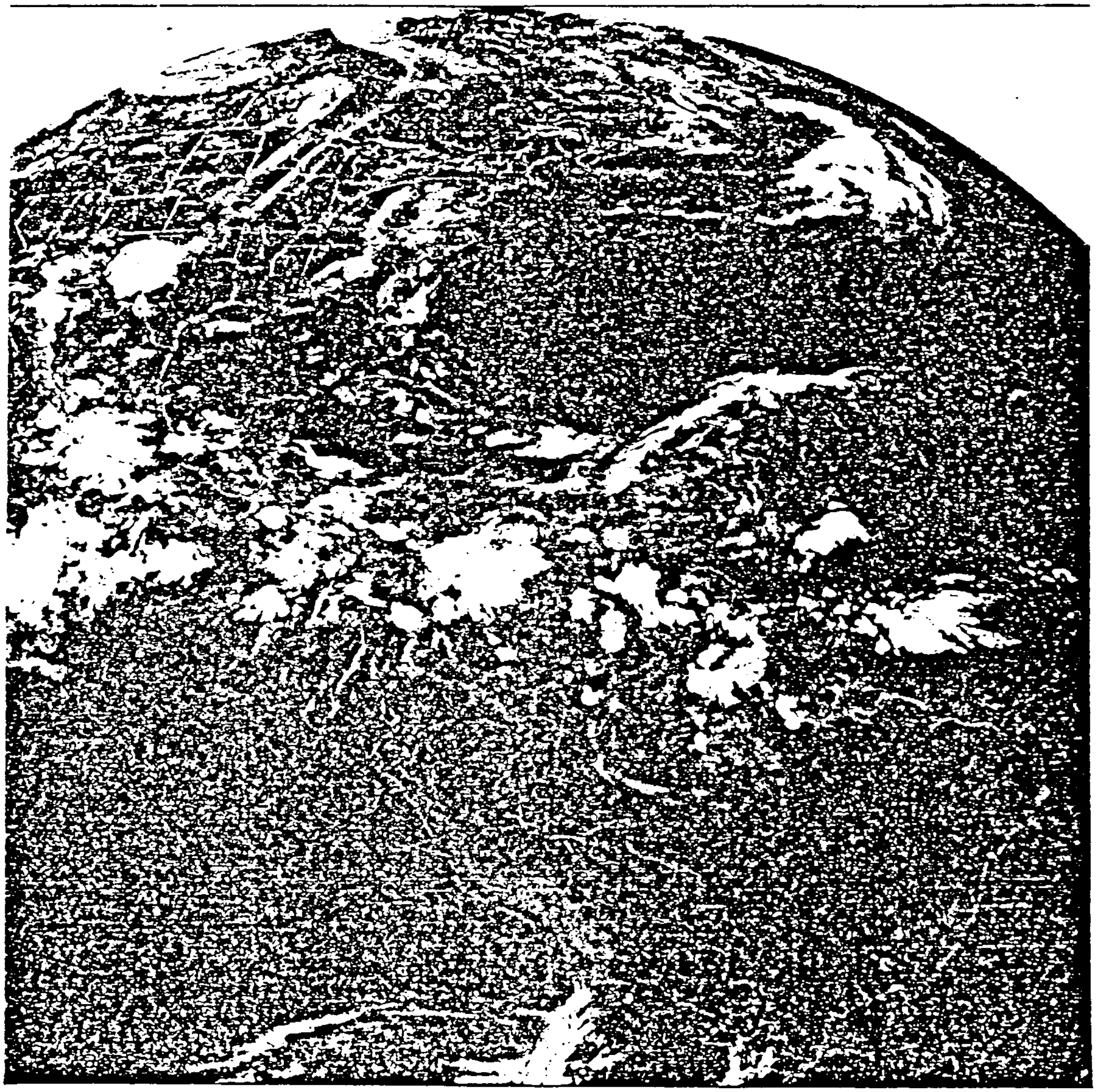


FIGURE 14 Example of X-Format (Infrared)

5. THE DIGITAL TRANSMISSION FORMAT

5.1. Definition of Terms

Formats are structured into Subframes and Frames.

FORMAT:
Data-Set used for the transmission of image information.
A-Formats : AV, AI, AIVW...
B-Formats : BV, BI, BIVW . . .
X-Formats : XI, XV, XIV . . .

PRAMES:
Each Data Frame consists of 364 *words* of **8** bits.

SUBFRAMES:
Subframes consist of 4 or 8 frames as follows:
A-Format-Subframes = 8 Frames
B- *or* X-Format Subframes = 4 Frames

DEFINITION FRAME / SUBFRAME:

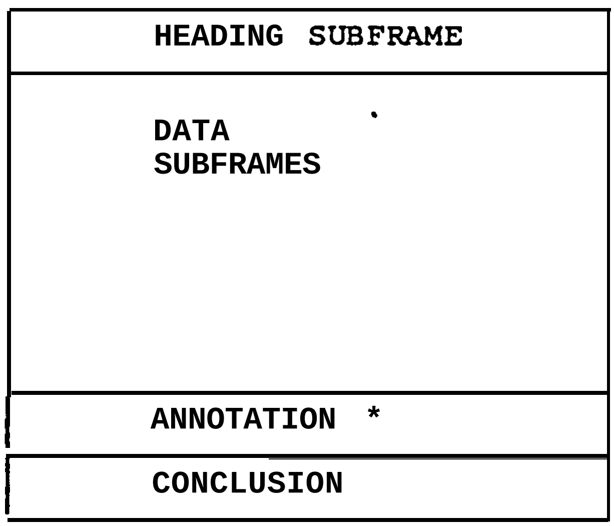
1.	364 words of 8 bits	1 Frame
2.		B-Format Subframe (frames 1–4)
3.		
4.		
5.		A-Format Subframe (frames 1–8)
6.		
7.		
8.		

5.2. Format Construction

A complete Format consists of the following sets of Subframes:

1. Heading Subframes
2. Image Data and Grid Information Subframes
3. Annotation Subframes *
4. Conclusion Subframes

FORMAT CONSTRUCTION



* B-Formats only

5.3. Elements of Subframes

Before the **construction** of Subframes **is** explained In detail It is necessary to describe Identification, **synchronisation,** interpretation and other data fields used in the Subframes.
These data are:

- Synchronisation Word
- ID-Word
- Label
- Identification
- Interpretation Data
- Fillers: **SP1,** SP2, SP4, SP5, and SP6
- Grid Information

5.3.1. Synchronisation Word

The **Synchronisation** Word is identical in all Subframes.
It consists of 3 bytes as follows:
(MSB) 00000101 00001100 **11011111 (LSB)**
MSB = Most Significant Bit
LSB = Least Significant Bit

5.3.2. ID-Word

The ID-Word consists of 1 byte (8 bits). The value of the ID-Word is increased by 1 for **each** Frame within a Subframe.

The first ID-Word of the **first Frame in** each A-Format **Subframe** is:
(MSB) 01110000

Due to the fact that the A-Format Subframes consist of **8 Frames**, the ID-Word of **the last** Frame in each A-Format **Subframe** Is:

(MSB) 01110111

The ID-Word of the first Frame in each B-Format and X-Format **Subframe** is:

(MSB) OOiiOOOO

Due to the fact that B- and X-Format Subframes consist of 4 Frames, the ID-Word of the last Frame In each B- or X-Format **Subframe** is:

(MSB) 00110011

By interpretation of the ID-Word it is easy to distinguish between A- and B- **or** X-Formats. The difference between both is in bit 2 of the **ID-Word** which **is:**

1 for A-Formats
and
0 for B- and X-Formats

5.3.3. Label

The contents of the Label are as follows:

<u>Bytes</u>

1 + 2 Number of Frames in the Subframe:
8 for A-Formats
4 for B- and X-Formats

Bytes	
3 + 4	Total number of Subframes in the Format counting all header Subframes as 1 and all conclusion Subframes as 1. (The total number of Subframes therefore is 2 plus the amount of Data and Annotation Subframes).
5 + 6	Current **Subframe** Number The current **Subframe** Number for all Header Subframes and all Conclusion Subframes = 1. The counting of Data Subframes starts with Ø for the first Data Subframe. The first Annotation **Subframe** has the **current Subframe** number 625.
7 + 8	Image Line Number The Image Line Number is Ø in **the Header,** Annotation and Conclusion Subframes. In **A-** and X-Formats the first Image Line Number = **1,** in %-Formats the first Image Line Number = 1810. In all cases, the Image Line Number increases by 1 for **each** set of Subframes.
9 + 10 11 + 12	Image Number from start of the Mission
13	Format Indicator (hexadecimal) **A = ØØ** **B =** FF X = **ØF**

Bvtes	
14, 15, 16, 17	Indicators of spectral information in the Subframe Byte 14 = VIS 1 Byte 15 = VIS 2 Byte 16 = IR Byte 17 = WV These indicators are set to the following hexadecimal values: ØØ if corresponding data are not represented in the Subframe FF If corresponding data are represented in the Subframe Due to the fact that subframes containing full resolution VIS Information contain only half lines bytes 14 and/or 15 are used In Data Subframes as follows: FØ if 1st half of VIS line is present in the Data Subframe ØF if 2nd half of VIS line is present in the Data Subframe In Data Frames containing reduced VIS information (AIVH-Format) bytes 14 or 15 are set to FF.
NOTE	Header Subframe Bytes 14 and 15 Indicate only that spectral information is present In the following transmission. Bytes 14 and/or 15 can be FF or ØØ:

Bytes

18 Indicator of Grid Information:
ØØ if no Grid Information is present
ØF if reference Grid Information is present

19 Indicator of Annotation Text:
FF if Annotation Text is present
ØØ if Annotation Text is not present

20 Indication of Scan Direction:
ØØ if Scan is S-N and E-W
FØ if Scan is N-S and E-W
ØF if Scan is S-N and W-E
FF if Scan is N-S and W-E
Normally Byte 20 has the hexadecimal value ØØ for METEOSAT (A- and B-Formats) and FF for GOES Belay Information (X-Format)

21 + 22 Spare bytes
23 + 24 All bytes are set to ØØ

5.3.4. Identification

Bytes

1 + 2 Satellite Indicator
The Satellite Indicator is used to give information about the image source of the transmitted format:

GOES	= ØØØØ (hexadecimal)	
METEOSAT 1	= D4E3 = MT	(EBCDIC - CODE)
METEOSAT 2	= D4F2 = M2	(")
$METEOSAT_n$	= $D4F_n$ = Mn	(")

Bytes

3 + 4	Year of **Image Acquisition** ***This* information is coded in binary values, e.g., 1982.**
5 + 6	**Day of Image Acquisition** **This information is coded in binary values, e.g., 346 for the 346th day of the year.**
7 + 8	**Nominal** Image Time This information is coded in binary (BCD - Binary Coded Decimal) and indicates Hour and Minute of completion of Image Acquisition, e.g., 0000 - 2330.
9 +10)	As for the
11+12)	Label
13-20)	in Header Subframes
21-32	Spare bytes all set to ØØ

5.3.5. Interpretation Data

The Interpretation Data Block consists of 1360 bytes and is designed for information on satellite orbit, geographical correction methods used, calibration coefficients and-administrative messages.

5.3.6. Fillers

Fillers were included to the Data Transmission in order to keep Subframes at a fixed structure. The fillers are as follows:

SP1	=	8 bytes, all set to ØØ
SP2	=	16 bytes, all set to ØØ
SP3	=	Not in use
SP4	=	1440 spare bytes (4x360), all set to ØØ
SP5	=	40 bytes, all set to ØØ
SP6	=	8 bytes, all set to ØØ

5.3.7. Grid Information

Grid Information is enclosed in each Data Subframe. The n^{th} bit of the Grid Information corresponds to the n^{th} byte of the Image Data of the same Data Subframe. The bit is set to 1 if grid point is available.

The Grid Information of A-Formats consists of 316 bytes = 2528 bits.

The first 2500 bits are the Grid Information corresponding to 2500 image pixels within the Subframe. 28 spare bits are set to Ø.

The Grid Information of B-Formats consists of 158 bytes = 1264 bits.

The first 1250 bits represent the Grid Information to the 1250 image pixels transmitted within the Subframe, 14 spare bits are set to Ø.

X-Formats do not contain separate Grid Information. Grids and Coastlines are superimposed to the images. The Grid Information field (158 bytes) is set to Ø.

5.4. Construction of Subframes:

5.4.1. Heading Subframes

5.4.1.1. Heading Subframes of A-Formats

The Heading Subframes of A-Formats consist of 8 frames of 364 bytes each. The structure is as follows:

------------------------- 364 bytes -------------------------

SYNC	ID	LABEL	SP1	IDENTIFICATION	SP2	INTERPRET.DATA (280 bytes)
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	SP4				
SYNC	ID	SP4				
SYNC	ID	SP4				
SYNC	ID	SP4				

The Heading Subframe is transmitted 42 times for each A-Format.

5.4.1.2. Heading Subframes of B- and X-Formats

The Heading Subframes of B- and X-Formats consist of 4 frames of 364 bytes each. The ettucture is as follows:

------------------------ 364 bytes ------------------------

SYNC	ID	LABEL	SP1	IDENTIFICATION	SP2	INTERPRET.DATA (280 bytes)
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	INTERPRETATION DATA (360 bytes)				

The Heading Subframe is transmitted 84 times for B-Formats and 90 times for X-Formats. .

5.4.2. Data Subfraree

5.4.2.1. A-Format Data Subframes

A-Format Data Subframes consist of 8 frames of 364 bytes each. The structure is as follows:

---------------- 364 bytes ----------------

SYNC	ID	LABEL	SP5	DATA (296 bytes)
SYNC	ID	DATA		(360 bytes)
SYNC	ID	DATA		(360 bytes)
SYNC	ID	DATA		(360 bytes)
SYNC	ID	DATA		(360 bytes)
SYNC	ID	DATA		(360 bytes)
SYNC	ID	DATA		(360 bytes)
SYNC	ID	DATA (44 bytes)		(316 bytes) GRID

Each A-Format Data Subframe includes 2500 bytes of Image Information. This corresponds to 2500 Image pixels and represents either one complete line of an IR or WV Image or half a line of one VIS channel image (different for AIVH formats).

5.4.2.2. B- and X-Format Data Subframes

B- and X-Format Data Subframes consist of 4 frames of 364 byte6 each. The structure is as follows:

SYNC	ID	LABEL	SP6	DATA (328 bytes)	
SYNC	ID	DATA (360 bytes)			
SYNC	ID	DATA (360 bytes)			
SYNC	ID	DATA (202 bytes)			(158 bytes) GRID

------------------------ 364 bytes ------------------------

Each B-Format Data Subframe include6 1250 bytes of Image information. This corresponds to 1250 image pixels and represents one complete B-Format line of IR or WV image or half a B-Format line of one VIS Channel image.

5.4.3. Annotation Subframes

These-frames are no longer transmitted.

5.4.4. Conclusion Subfrares

The Conclusion Subframe is a copy of the Heading Subframe.

The amount of Conclusion Subframes transmitted in the individual Transmission Format is:

One for all A-Formats
for BI, BIV, BW, BVW AND X-Format6
Two for BIW, BIVW and BV.

5.5. Sets of Data Subframes

A set of Data Subframes represents one Image Line of all Spectral Channels included in the individual Transmission Format.

A set of Data Subframes therefore consists of one or a combination of the following elements:

One Subframe of IR Data
Two Subframes of VIS2 Data
Two Subframes of VIS1 Data
or
One Subframe of WV Data

Consequently, the number of Data Subframes in a set of Subframes is varying in accordance with the number of Spectral Channel Information included in the Transmission Format. The formats include the following information:

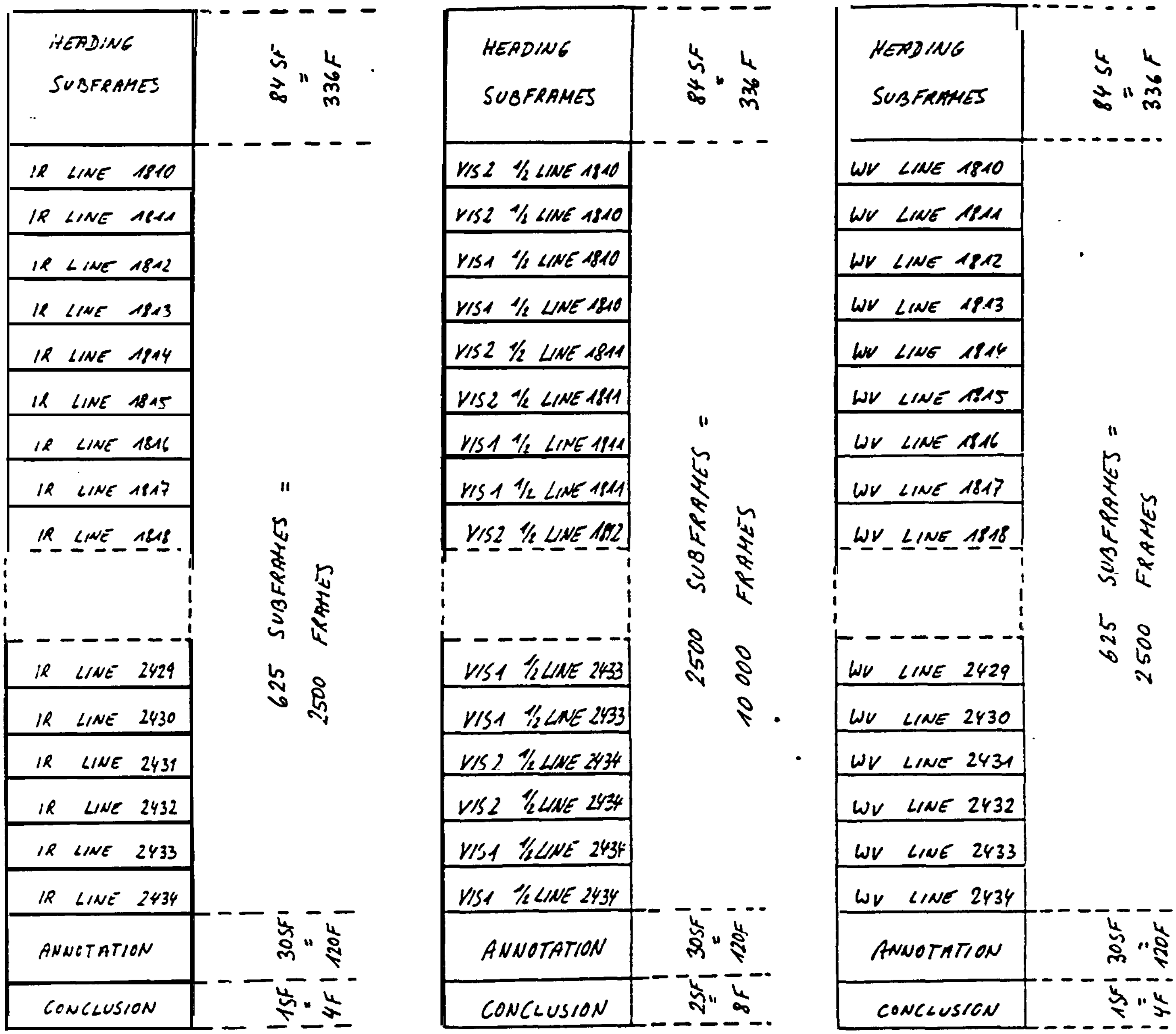
AI, BI, XI	Subframe	IR only
AIV, BIV, XIV	Subframes	IR + VIS2 + VIS1
AIW, BIW	Subframes	IR + WV
AIVW, BIVW	Subframes	'IR + WV + VIS (2 or 1)
AW, BW	Subframe	WV only
AV, BV	Subframes	VIS only (VIS1 + VIS2
AIVH	Subframes	Reduced VIS (2 or 1) + IR

Within the sets of Subframes the Data Subframes of the different Spectral Information are transmitted in the sequence:
IR, VIS2, VIS1 (or WV)

5.6. Transmission Formats

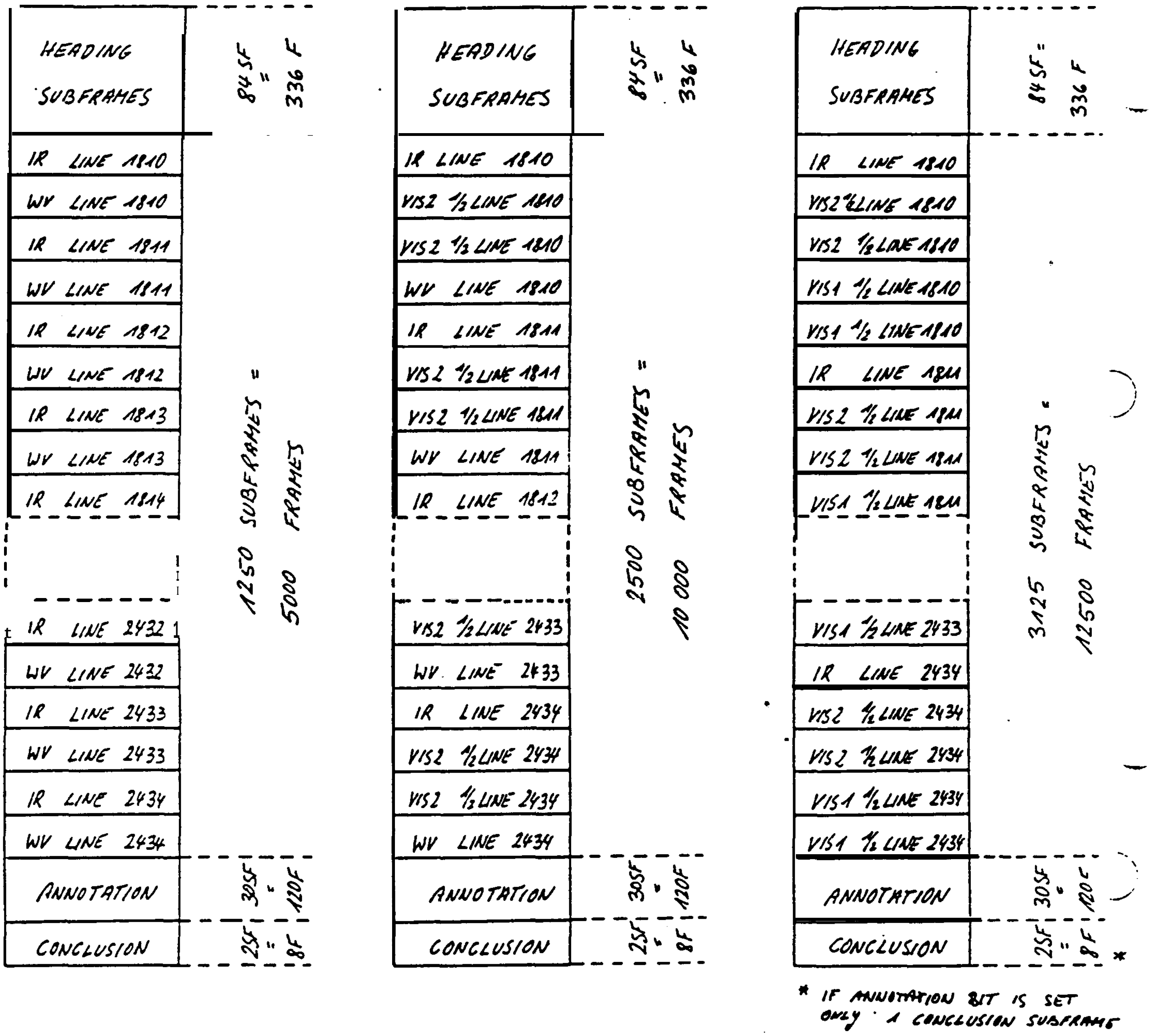
A list of available Transmission Formats is given in Chapters 4.1.1. (A-Formats), 4.1.2. (B-Formats) and 4.2.1. (X-Formats). For better understanding, the construction of some Transmission Formats is shown in Figures 15, 16, 17 and 18.

In case that information of one Visible Channel is not available, the information of the other Visible Channel is repeated in Formats AV, BV, AIV and BIV.



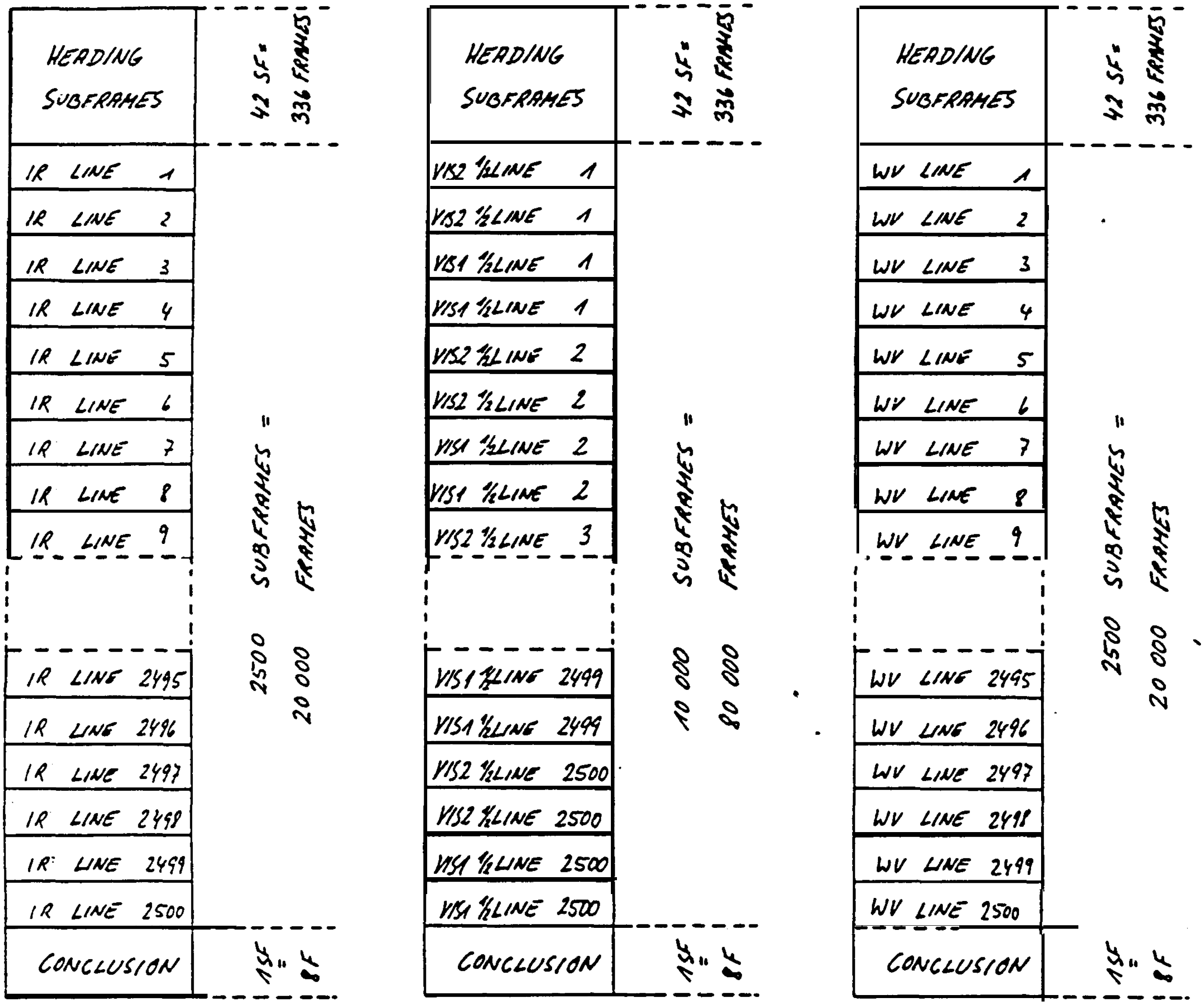
BI BV BW

FIGURE 15 Examples of BI, BV and BW-Formats



BIW   BIVW   BIV

FIGURE 16   Examples of Formats, BIW, BIVW, and BIV



AI AV AW

FIGURE 17 Examples of AI, AV, and AW-Formats

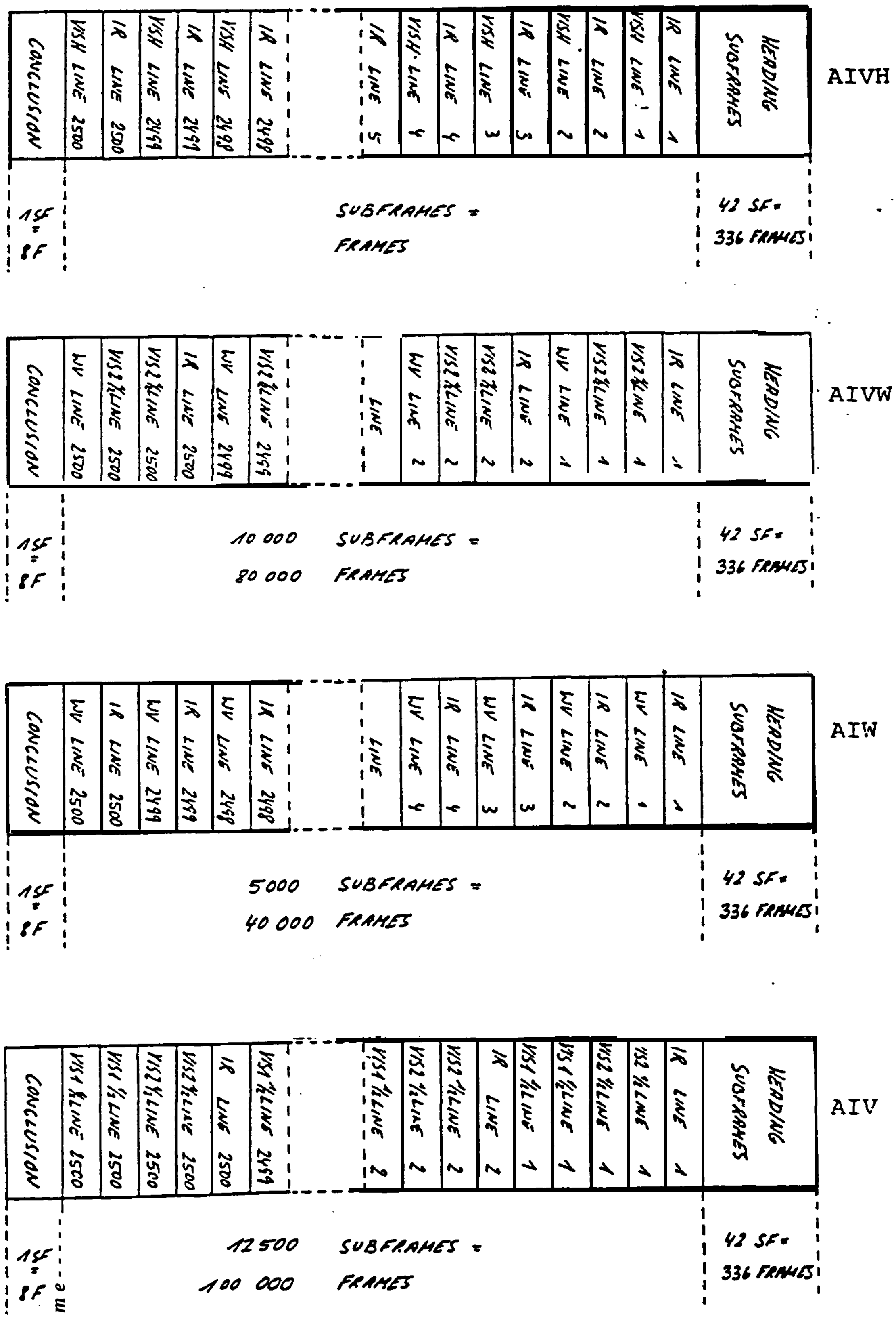


FIGURE 18 Examples of AIVH, AIVW, AIW and AIV-Formats

5.7. File Layout of Interpretation Data

The "Interpretation Data" black contains 1360 bytes and organised as follows:

1. Calibration Data (104 bytes)
2. Spacecraft Operations Data (128 bytes)
3. Imagery Data (328 bytes)
4. Administrative Messages (800 bytes)

5.7.1. Calibration Data

OFFSET	NAME	TYPE	LENGTH	CONTENT
0	BBC	ASCII	5	Normalized Black Body Count xxx.xx
5	SDBBC	ASCII	3	Standard deviation for BBC x.xx
8	TIME1	ASCII	5	DDDSS (Day =D, Slot =S) Timestamp for BBC
13	IRCAL	ASCII	5	IR-Calibration value 0.0XXXXX
18	TIME2	ASCII	3	Timestamp for IR-Calibration value (DDD)
21	WVCAL	ASCII	4	Water vapour calibration value o.ooxxxx
25	TIME3	ASCII	3	Timestamp for WV-Calibration value (DDD)
28	GAINS	ASCII	8	Gains for IR, WV,VIS1 & VIS2 GiGiGwGwGvGvG2G2
36			68	Spare for future use

5.7.2. Spacecraft Operation Data

OFFSET	NAME	TYPE	LENGTH	CONTENT
104	DEGSRA	R*8	8	Right ascension attitude south in degrees
112	DEGSDE	R*8	8	Declination attitude south in degrees
120	DECNRA	R*8	8	Right ascension attitude north in degrees
128	DEGNDE	R*8	8	Declination attitude north in degrees
136	FINATT	R*8	24	X, Y, Z of refined attitude
160	FARADE	R*8	16	Right ascension and declination of mean refined attitude
176	NRSLOT	I*4	4	Number of slots for refined attitude
18.0	SPNDUR	R*4	4	Spin duration minus nominal spin duration in microseconds
184	FLECL	L*1	1	Eclipse operation
185	PLDEC	L*1	1	Decontamination
186	FLHAN	L*1	1	Manaeuvre
187	FLMODE	L*1	1	TRUE-earth, FALSE-sun
188	FLIR1	L*1	1	IR1 on
189	FLVIS1	L*1	1	VIS1 an
190	FLVIS2	L*1	1	VIS2 on
191	FLWV	L*1	1	WV on
192	FLIR2	L*1	1	IR2 on
193			39	Spare for future use

5.7.3. Imagery Data

OFFSET	NAME	TYPE	LENGTH	CONTENT
232	IMSTAT	L*1	16	1 Horizon analysis 2 Spin speed fit 3 Orbit offset vector fit 4 Pixel sampling rate fit 5 Attitude refinement iteration based on horizon results 6 Not in use 7 Not in use 8 Calculation of deformation vector field 9 Not in use 10 Completion of rectification 11 Canpletion of amplitude processing 12- 16 Spare
248	LIMHOR	I*2	24	Southern line, 1. pixel/last pixel Northern line, 1. pixel/last pixel East pixel, south line/north line West pixel, south line/north line

OFFSET	NAME	TYPE	LENGTH	CONTENT
272	SATDIS	R*8	8	Distance satellite - earth centre
280	SORBOF	R*8	24	x, y, z components of orbit offset vector in nominal image frame at southern horizon limit
304	NORBOF	R*8	24	x, y, z components as above at northern horizon limit
328	XDDIFM	R*4	4	Max. deformation difference x-canponent within column
332	YDDIFM	R*4	4	Max. deformation difference y-canponent within lines
336	XSCM	R*4	4	Max. deformation difference x-canponent within lines
340	YSCM	R*4	4	Max. deformation difference y-canponent within columns
344	CONDS	L*l	4	1. Earth within field of view in east/west 2. Earth within field of view in south/north 3. East/west horizon limits within predicted margin 4. South/north horizon limits within predicted margin
348	LOWDYN	I"2	10	Lowest non-zero count in histogram (-1 if off) for IR1, VIS1, VIS2, WV and IR2

OFFSET	NAME	TYPE	LENGTH	CONTENT
358	HIGDYN	If2	10	Highest non-zero count in histogram (-1 if off) for IR1 VIS1, VIS2, WV and IR2
368	MVIS1	R*4	4	Mean vaiue of VIS1
372	MVIS2	R*4	4	Mean value of VIS2
376	SNNOM	R*4	12	IR1/IR2, VIS1/WV, VIS2 nominal reference count signal to noise ratios
388	SNNLIN	I*4	4	Number of lines used for S/N calculation
392	SNREP	R*4	12	S/N ratios eastern part for IR1/IR2, VIS1/WV and VIS2
404	SNRWP	R*4	12	S/N ratios western part for IR1/IR2, VIS1/WV and VIS2
416	SWMNEP	R*4	12	Mean signal value eastern part for IR1/IR2, VIS1/WV and VIs2
420	SNMNWP	R*4	12	Mean signal value western part for IR1/IR2, VIS1/WV and vIS2
440	SNMXEP	I*2	6	Maximum space count eastern part for IR1/IR2, VIS1/WV and VIs2
446	SNMXWP	I*2	6	Maximum space count western part for IR1/IR2, VIS1/WV and vIS2
452				108 spare bytes for future use'

5.7.4. Administrative Messages

OFFSET	NAME	TYPE	LENGTH	CONTENT
560	ADMNS	ASCII	800	Administrative Messages

5.8. Content of Interpretation Data

5.8.1. Calibration Data

5.8.1-l. Normalised Black Body Count (BBC)

The Black Body Count (BBC) to be transmitted is that normalised to a temperature of 290K. Variations in the normalised BBC can be considered to provide information on variations in response of the radiometer and can thus be used to fine tune the MIEC IR calibration value. This is done by calculating the FAG-Factor (Fine Adjustment of Gain) from the normalised BBC. The reference value for the nonnalised BBC has been chosen as 110 and the FAG Factor is defined as 110/BBC. The corresponding radiance value for a measured IR count is given by:

$$R = (\text{Count} - 6) \times \text{CAL} \times (110/\text{BBC})$$

where CAL is the MIEC IR calibration value.
Temperatures can be derived using a table relating Radiances to Planck Temperatures.

The figure to **be** sent in the interpretation data is normalised BBC represented by five ASCII figures which have to be read **as follows:**

XXX.XX

Only the five X figures are transmitted where the last two figures are the decimals of the normalised BBC.

5.8.1.2. Standard Deviation for BBC (SDBBC)

This value represents the difference between the last two BBC measurements and gives an indication on the present development on the radiometer response.

Three ASCII characters are transmitted. The first represents the total, the two others the-decimals of the value **(X.XX).**

5.8.1.3. Timestamp for BBC (TIME1)

This timestamp represents the day and slot of the last BBC measurement. The timestamp is transmitted as 5 ASCII characters in the following layout:

DDDSS

DDD = Day of the year
SS = Slot of the day

5.8.1.4. **IR-Calibration** value **(IRCAL)**

The **IR-Calibration** value is that used in MIEC (Meteorological Information Extracting Centre at ESOC) processing to convert from IR Counts to radiances. It is updated as necessary as a result of canparisons between sea surface temperatures derived from METEOSAT image data and those from conventional ship measurements. The five ASCII characters transmitted should be interpreted as follows:

0.0XXXXX

5.8.1.5. Timestamp for IR Calibration Value **(TIME2)**

This timestamp represents the day of the year (DDD) when the IR-Calibration value was introduced.

5.8.1.6. Water Vapour Calibration Value **(WVCAL)**

The WV-Calibration value is that used in MIEC-processing to convert from WV counts to radiances. It is updated as necessary as a result of comparisons between radiosonde data and Upper Tropospheric Humidity data calculated from METEOSAT image data. The four ASCII characters transmitted should be interpreted as follows:

0.00XXXX

5.8.1.7. Times&up for WV-Calibration Value (TIME3)

This timestamp represents the day of the year (DDD) when the WV-Calibration value was-introduced.

5.8.1.8. Gains (GAINS)

The actually selected gains of all spectral bands are transmitted in 8 ASCII characters with the following layout:

GiGiGwGwGvGvG2G2

GiGi = Gain IR
GwGw = Gain WV
GvGv = Gain VIS1
G2G2 = Gain VIS2

The gain represents an amplification factor of the radiometer electronics. The gain can be selected by telecommand between 00 and 15.

The transmission of two blanks in one of the gain patterns indicates that this spectral channel is switched off.

The purpose of the gain change is to correct for variations in the radiometer response so that the maximum voltage variation in the sensor output analogue signal corresponds to the maximum radiance variation experienced by the radiometer.

In nominal operations, the gain settings are chosen in a way that the individual detector is only marginally saturated at the warmest (IR) or brightest (VIS) image slot of the day. However, for special projects, a gain setting could be selected to enhance lower radiances, if interest is only in these. This would result in saturation of the higher radiances.

5.8.2. Spacecraft Operations Data

This data set describes the satellite position in space. The coordinate frame used for this description is called γ 50 and is related to the spring equinox in the year 1950. The coordinate frame is an intertial frame with its origin in the Earth's centre. The X-axis points in the direction of mean vernal equinox. The Z-axis points in the direction of celestial north (the' star Polaris) and the Y-axis forms the 3rd member of the trihedron. Figure 19 shows the coordinate frame γ 50.

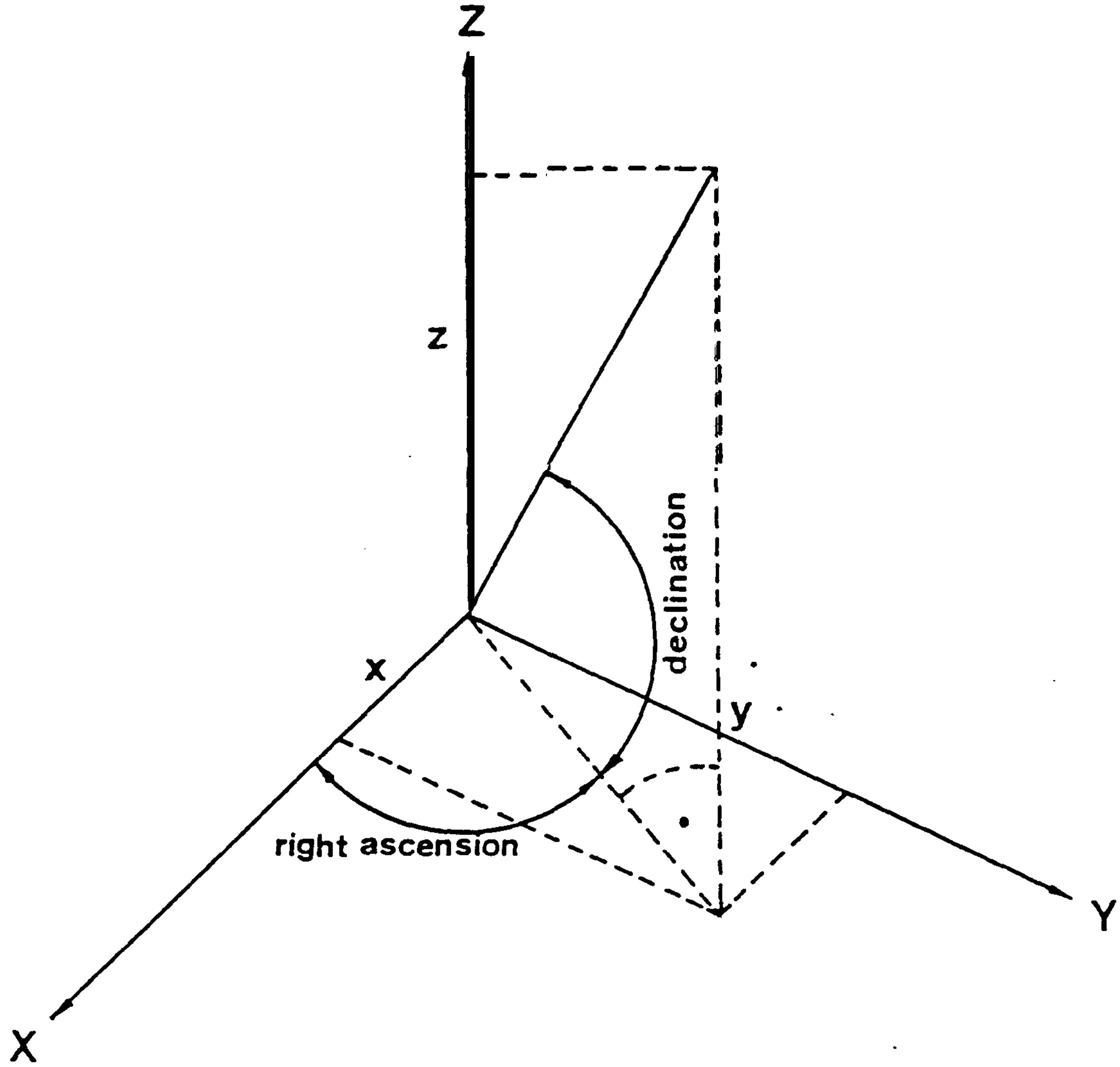


FIGURE 19 Coordinate System ♈ 50
(Spring Equinox in 1950)

5.8.2.1 Right ascension attitude south in degrees (DEGSRA)

This value' describes the angle between the X-axis and the vector formed by the projection of the attitude vector (momentary axis of rotation) projected onto the XY level. This value is measured during the scanning of the southern image part.

5.8.2.2 Declination attitude south in degrees (DEGSDE)

This value describes the angle between the attitude vector and its projection on the XY level. This value is measured during scanning of the southern image part.

5.8.2.3 Right ascension attitude north.in degrees (DEGNRA)

This is the value corresponding to 5.8.2.1 but measured during scanning of the northern image part.

5.8.2.4 Declination attitude north in degrees (DEGNDE)

This is the value corresponding to 5.8.2.2 but. measured during scanning of the northern image part.

5.8.2.5 X, Y, Z of refined attitude (FINATT)

These are the values of projected attitude vector X, Y, and Z canponents (see Fig. 19, values X, Y, Z) based on the refined attitude. This is a mean of attitude vectors over nominally 48 slots.

5.8.2.6. Right ascension and declination of mean refined attitude (FARADE)

This is a mean of the last (nominally 48) values of the right ascension and declination.

5.8.2.7. Number of slots for refined attitude (NRSLOT)

This is the amount of slots (nominally 48) used for calculation of the refined attitude. This-amount of slots was used for calculation of values 5.8.2.5. and 5.8.2.6.

5.8.2.8. Spin duration (SPNDUR)

This time is measured during scanning of line 1250 nominally (middle of the image) corresponding to.nominal radiometer position 1350. The value transmitted is the measured spin duration in usec minus the nominal spin duration (600 000 µsec).
If the satellite rotation is faster than nominal the value will be negative.

5.8.2.9. Flags for special operation modes

The various operation modes are indicated by a L*1 value. If the value is set 1 the operations mode was active during acquisition of the image. The values are:

FLECL - Eclipse Operation
FLDEC - Decontamination of the radiometer is operated
FLMAN - S/C manoeuvre was performed
FLMODE - Satellite is in Earth mode if value is 1
in Sun mode if value is Ø
FLIR1 - IR1 switched on
FLVIS1 - VIS1 on
FLVIS2 - VIS2 on
FLWV - WV on
FLIR2 - IR2 on

5.8.3. Imagery Data

These data are produced during image processing in the MGCS-MF. They are intended to inform the user on the amount of processing which was necessary to move the original raw image into a reference frame. In addition, information on amplitude analysis will be provided. The data are:

Image and'processing status information
Radiometer step offset at image start
Satellite position (distance, attitude, orbit)
Conditions resulting from horizon analysis
Amplitude analysis (dynamic ranges)

5.8.3.1. **Image and processing status information (IMSTAT)**

These data are represented by 16 **L*1** values which are set 1 **(.TRUE.)** if the corresponding item was successfully completed **(Ø = .FALSE.)**. The 16 bytes are dedicated as follows:

1	Horizon analysis
2	Spin speed fit
3	Orbit offset vector fit
4	Pixel sampling rate fit
5	Attitude refinement iteration based on horizon results
6	Not in use
7	Not in use
8	Calculation of deformationvector field
9	Not in use
10	Canpletion of rectification
11	Completion of amplitude processing
12 - 16	Spare

5.8.3.2. Southern line **etc (LIMHOR)**

The groups of values in LIMHOR indicates the position of the Earth as seen during scanning. The 12 values are (see Fig. 20):

1	Southern line:.	The number of the first scanning linecontaining Earth information

2	**1. pixel** :	The column of the first detected pixel in the first line containing Earth information
3	Last pixel :	As above, but the column of the last detected Earth pixel in the line
4	Northern Line:	The number of the last scanning line containing Earth information
5	1. pixel :	The column of the first detected pixel in the last line containing Earth information
6	Last pixel :	As above, but the column of the last detected Earth pixel in the line
7	East pixel :	The right most pixel (column number) inthe image
a	South line :	Number of the first scanned line containing the right most pixel
9	North line :	Number of the last scanned line containing the right most pixel
10	West pixel :	The left most pixel (Column number) inthe image
11	South line :	Number of the first scanned line containing the left most pixel
12	North line :	Number of the last scanned line containing the left most pixel

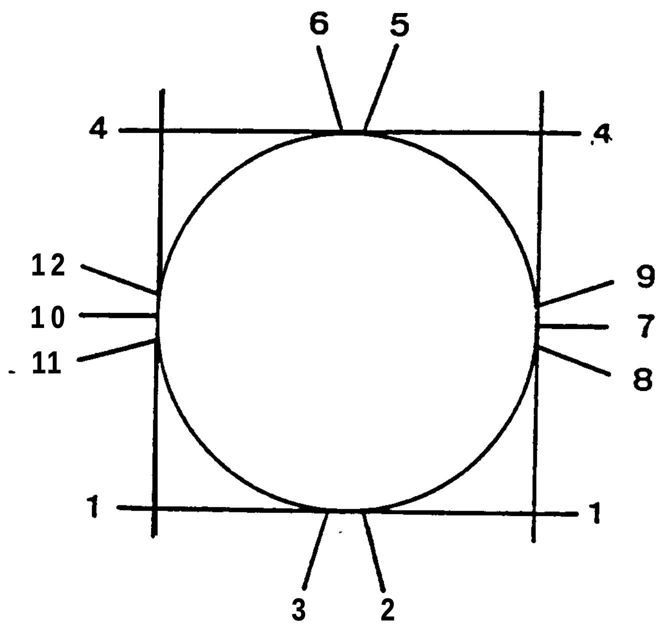


FIGURE 20 Position of the Earth during Scanning (LIMHOR)

5.8.3.3. Distance Satellite-Earth Centre (SATDIS)

This double precision value indicates the distance of the satellite to the Earth centre in km at the time of scanning the Earth centre.

5.8.3.4. X, Y, Z Components (SORBOF, NORBOF)

These values indicate the level of changes to the image during image geometry corrections. For the description of the image geometry the following set of coordinate systems is used:

- The nominal image frame (NIF) with origin at nominal satellite position N, Xn-axis pointing towards the earth centre and Zn=0 being the equatorial plane.

- The actual image frame (AIF) with origin at momentary satellite position S, Xa-axis pointing towards the earth, Za-axis coinciding with attitude vector a and the earth centre always being in the plane Ya = 0. Generally this frame is moving with each scan step of the radiometer.
  (In the subsequent description the subscripts "a" and "n" refer to AIF and NIF respectively).

  The principal idea of the image geometry model is then to adjust the actual image frame at position of southern respectively northern horizon limit scans and to express its movement (offset vector and Euler angles) with respect to the nominal image frame as functions of the radiometer scan step. Conservation of angular momentum of the spacecraft (except for manoeuvres) is used for determining an approximate mean attitude vector as starting point for an iterative attitude refinement procedure per image.

Since infrared radiation even at the polar caps of the earth differs at all times significantly from thermal noise corresponding to space the southern and northern horizon scan limits can well be extracted from the infrared image.

In order to get these positions accurate to part of a pixel a parabola arc is fitted to the horizons. The radiation threshold value defining the horizon and the apparent radius of the earth are adjustable parameters in order to compensate for the thickness of the atmosphere.

Figure 21 illustrates the coordinate systems for description of image deformations. The values ρx, ρy, ρz correspond to the X, Y, Z values in SORBOF, NORBOF.

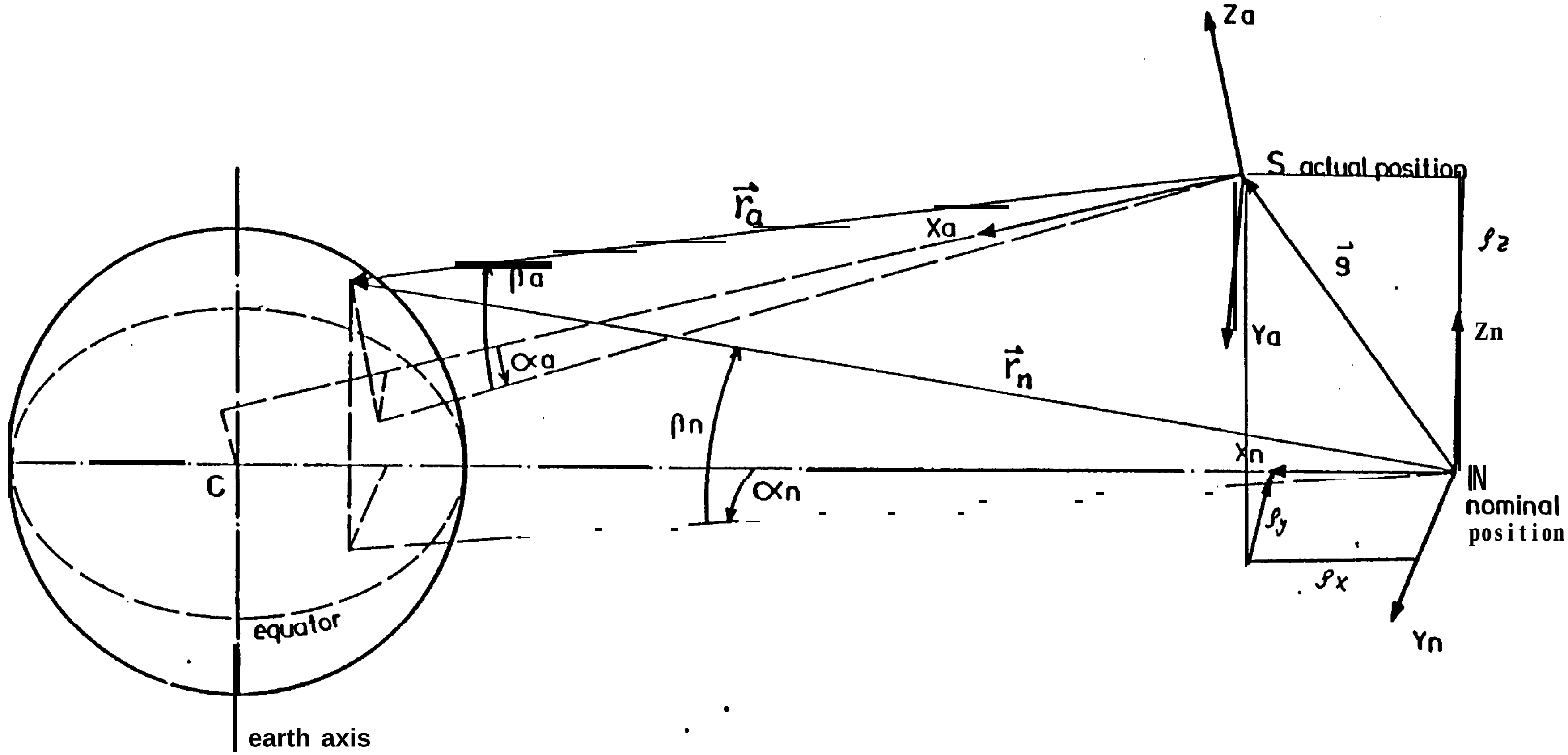


Figure 21 Coordinate system for description of image deformations.
The earth center C is always in the planes $y_a = 0$ and $y_n = 0$.

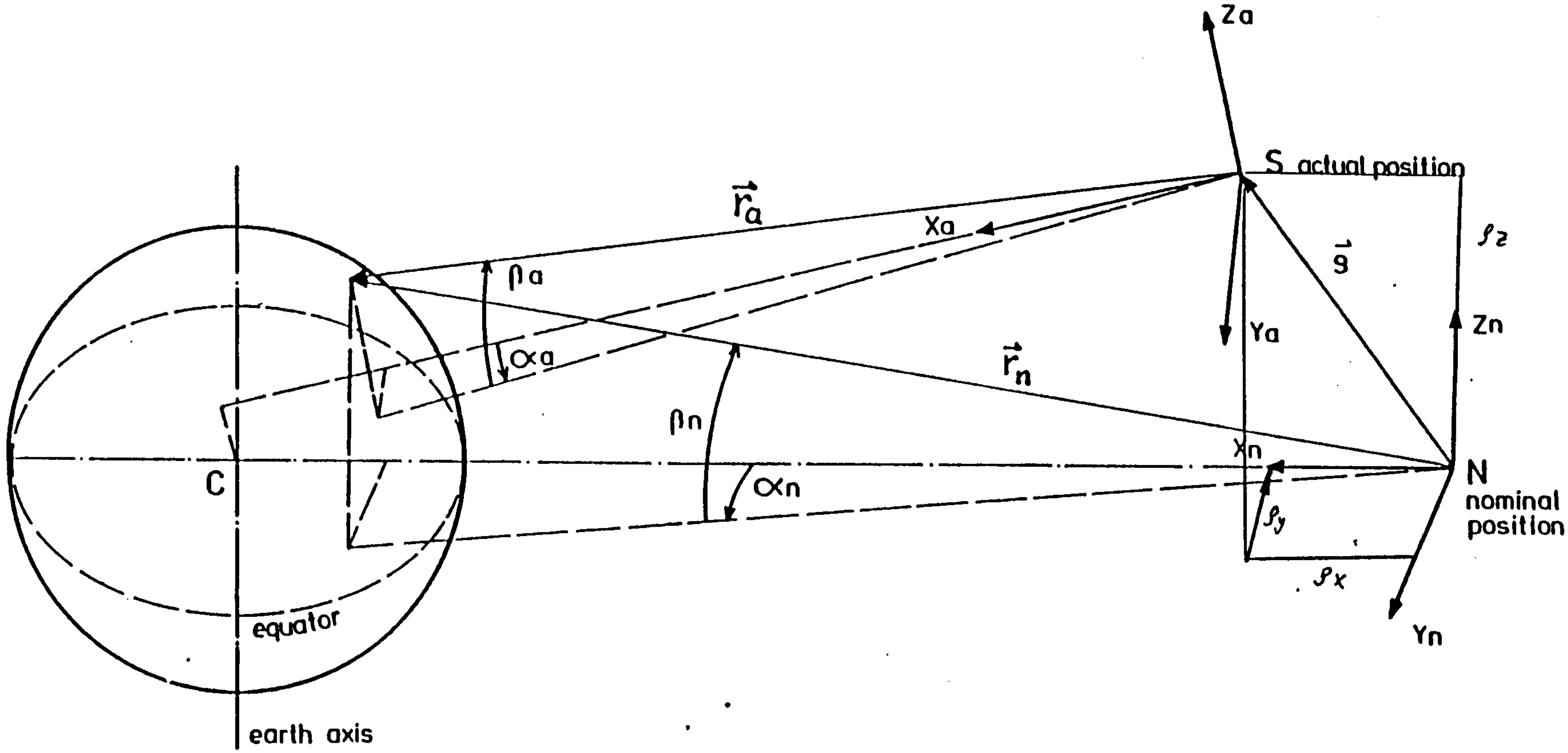


Figure 21 Coordinate systems for description of image deformations.
The earth center C is always in the planes $y_a = 0$ and $y_n = 0$.

5.8.3.6. Image Conditions (CONDS)

These logical values are set .TRUE. when Earth was within the field of view during scanning. (1 for E/W, 2 for N/S). 3 and 4 are set .TRUE. when the scanned Earth image was within ± 3 pixels from the predicted values (see Figure-23).

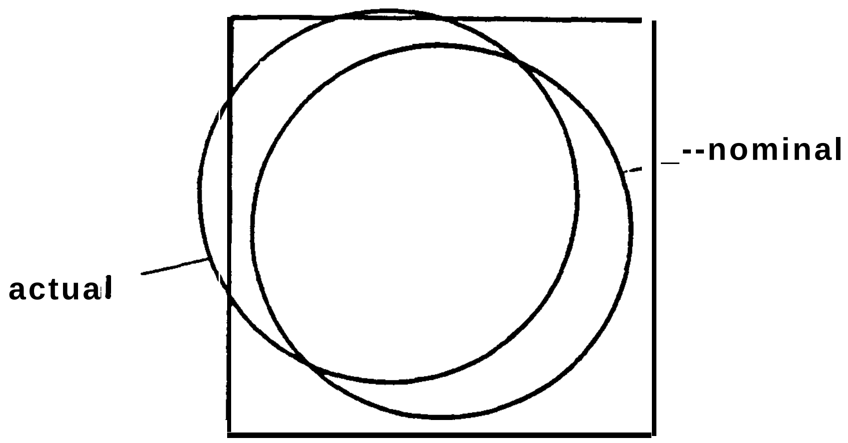
5.8.3.7. Image histogram information (LOWDYN, HIGDYN, MVIS1, MVIS2)

These values indicate the dynamic of the individual spectral channels.

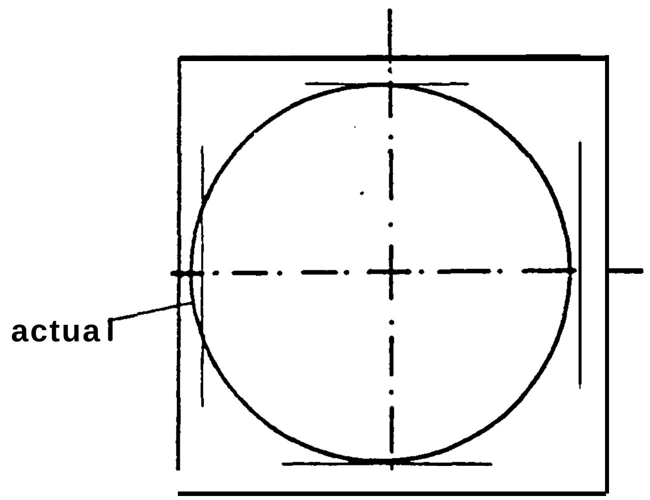
LOWDYN indicates the lowest count in the histogram for IR1, VIS1, VIS2, WV, and IR2 (in this order). If the channel is switched off the value -1 is transmitted. HIGDYN is the highest count (contrary to LOWDYN).

MVIS1 and MVIS2 represent the mean value of VIS1 and VIS2 image pixels in space (measurement for noise in space).

All these informations could be used for image enhancement in order to make use of the full dynamic range of hard copy recorders or display units.



CONDS : Both .FALSE.
1,2 : 0



CONDS :1:1
2:1
3:0
4:1

FIGURE 23 Image Conditions (CONDS)

5.8.3.8. Signal-To-Noise Ratio Calculations (SNNOM, SNNLIN, SNREP, SNRWP, SWMNEP, SNMNWP, SNMXEP, SNMXWP)

These parameters give information on the quality of the radiometer during the -scanning.

For each channel the pixel values in space to either side of the Earth are examined to determine the noise level in this image part. The value is calculated as follows:

$$NS = SQRT\left(\sum_{J=1}^{P} J^{**}2^{*}K(J)/F\right)$$

where $F = \sum_{J=1}^{S} K(J)$

J represents the pixel value and K(J) is the number of pixels with value J

SNNOM contains the nominal reference count signal to noise ratios of IR1/IR2, VIS1/WV, VIS2

SNNLIN contains the amount of lines used for the above described S/N calculation

SNREP & SNRWP give the S/N ratios for western and eastern part

SWMNEP & give the mean signal value of western and
SNMNWP eastern part

SNMXEP & give the maximum space count of western
SNMXWP and eastern part

5.8.4. Administrative Messages

Up to 800 ASCII characters can be used for administrative messages. These are used to inform users about changes in operations of the METEOSAT system. The messages are marked with an "Administrative Message Number" which consists of the year and month of issue and a sequence number of messages issued in this month.

5.9 Format of Integer, Logical and Real Values in Interpretation Data

5.9.1. Integer type data (I*2, I*4)

Two-byte and four-byte integer types are represented as 16-bit and 32-bit binary numbers, respectively. The first bit indicates the sign. A positive integer is represented by a 0 in the sign bit and a binary true number representation in the remaining bits. A two's canplement with 1 in the sign bit represents a negative integer. All bits contain 0s to represent zero.

5.9.2. Logical data (L*1)

One-byte and four-byte logical data are represented as 8-bit and 32-bit binary numbers, respectively. A true value has 1 in the final bit with all remaining bits 0. A false value has 0s in all bits.

FORTRAN 77 determines that a logical data value is true when any bit is 1 (true), and that the value is false when all bits are 0 (false).

5.9.3. Real type data (R*4)

Real type data is represented as a 32-bit floating point number. The first bit indicates the sign. Seven bits following the sign bit indicate the exponent part, the remaining 24 bits constitute a six hexadecimal digit mantissa with each of the four bits representing a digit.

The hexadecimal radix point **of** the mantissa is to the left of the most significant mantissa digit. The exponent part represents a number in the range of 0 to 127. **It** represents an exponent in the range of -64 to 63, after subtraction of 64 from the actual exponent.

```
0         8   16       24       31
-----------------------------------
|S  |  E  |           M           |
-----------------------------------
```

5.9.4. Double **precision** data **(R*8)**

Double precision data is represented as a 64-bit floating point number. Its sign and exponent part are similar to those **in** real data. The mantissa consists of 56 bits following the exponent part **and** has 14 hexadecimal digits (each four bits represents a digit).

```
 0      8    16    24    32    40    48    56    63
------------------------------------------------------
|  S  |  E  |                  M                     |
------------------------------------------------------
```

S **:** eign (positive if 0 and negative if 1)
E : exponent. This value is obtained by adding 2^6 to the actual exponent.
M **:** hexadecimal mantissa part with the radix point to the left of bit 8.

Value = Man. $16^{exp.}$

6. METEOSAT DISSEMINATION SCHEDULE

The spacecraft has two dedicated dissemination channels which can be used for both analogue and digital transmission. At the preaent time the following philosophy is used to determine the METEOSAT dissemination schedule:

1) Channel 1 - 1694.5 MHz
   Analogue transmissions from ESOC-Darmstadt

2) Channel 2 - 1691.0 MHz
   All digital data (A, B and X formats transmitted to PDUS), plus all transmissions made from CMS Lannion (identified by L in the schedule) plus transmissions- of processed data (CTH, weather Charts).

In addition, administrative message6 are transmitted simultaneously on both channels in WEFAX format, and space is reserved on both channels simultaneously for the operation of METEOSAT Ranging measurements.

This concept is subject to modification at short notice for a variety of operational considerations, such as:

- reduced computer capacity
- availability of only one dissemination channel
- special eclipse operational mode
- maintenance considerations

METEOSATDISSEMINATION SCHEDULE S9409M01 VRLJD FROM01/09/84

```
HH     00 UT  I   03  UT  I   06 UT       09 UT    I   12    UT I   15  UT  I   18  UT  I   21 UT   I HH
MM CH1  . CH2 J  CH1 . CH2 I CH1 . CH2   CH1 . CH2 I CH1 . CH2 I  CH1  CH2 I CH1 . CH2 I CH1 . CH2 I MM
 2  E3  47:   I      .     IE3 11.WEFA  2          IE3  22: -- -- I    .   IIE3  34:  I  I        II  2
 6            I      .     I   .-- --              I     .-- --I                      I         I  6
10  D2 48 BIW 48ID2  6.BIW 6ID2 12. BIVW12 D2 18.BIVW18ID2 24. BIVW24ID2 30 BIVW30ID2 36.BIVW36ID2 42.BIW 421 10
14  D1 48.       ID1  6.    IC02 12.DTOT12 C02 18.      tCe2 24.DTOT24IC02 30     ID1 36.DTOT36ID1 42.     I 14
18  D3 48.AI 48ID3   6.AI  6IC03 12.AI 12 C03 18.AI 18IC03 24.AI 24IC03 30.AI 30ID3 36.AI 36ID3 42.AI 421 18
22  D4 48.-- --ID4   6.-- --ID1 12.-- - - D1 18.-- --ID1 24.-- --ID1 36.-- --104 36. -- --ID4 42.-- --I 22
26  D5 48.LY 48ID5   6.DTOT 6ID3 12.LY 12 D3 18.DTOT18ID3 24.LY 24ID3 30 DTOT30ID5 36.LY 36ID5 42.DTOT42I 26
30  D6 48.LR 48ID6   6.     ID4 12.LR 12 D4 18.ETOT18ID4 24.LR 24ID4 30.ETOT30ID6 36.LR 36ID6 42.      I 30
34  D7 48.DTOT48ID7  6.     ID5 12.ETOT12 D5 18.CTOT18ID5 24.ETOT24ID5 30.   ID7 36.WEFA 3ID7 42.      I 34
38  De 40.       ID8  6.    ID6 12.      D6 18.     ID6 24.CTOT24ID6 30.     ID8 36.-- --ID8 42.       I 38
42  D2  1 BIW 1ID2   7.BIW 7ID2 13.BIV 13 D2 19.BIV 19ID2 25.BIV 25ID2 31 BIV 31ID2 37.BIVW37ID2 43.BIW 431 42
46  D9  1.LX 48ID9   7.    IC02 13.LX 12 C02 19.AV 19IC02 25.LX 24IC02 31 AV 31ID9 37.LX 36ID9 43.    I 46
50  D1  1 -- --ID1   7.AI 7IC03 13.-- - - C03 1).-- -- IC03 25. -- --IC03 31.-- --ID1 37. -- --ID1 43.at 431 50
54  D3  1.AI  IID3   I.-- --IC3D 13.AI 13 C1D 19.-- --IC1D 25.AI 25IC1D 31 -- --IDS 37.AI 37ID3 43.-- --I 54
58         .-- --I          IC2D 13.-- - - C2D 19.-- --IC2D 25. -- --IC2D 31 -- --I      .-- --I         I 58

HH t   01 UT      04  UT  I   B7   UT I   10 UT       13 UT   I   t6 UT        19 UT   I   22 UT   I HH
MM  I CH1 CH2    CH1 . CH2    I CH1 . CM2 I  CH1 . CH2   CH1 . CH2 I CH1   CH2    CH1 . CH2 I CH1 .  CH2 I MM
 2 1       .                I    .    IC3D 19.-- - - C3D 25.    IC3D 31.-- --               I    .    I  2
 6 I       .                I    .    JC4D 19.-- - - C O 25.LZ 24IC4D 31. -- --              I    .    I  6
10 ID2  2.BIW  2 D2  8.BIW 8ID2 14.BIVW14ID2 20.BIVW20 D2 26.BIVW26ID2 32 BIVW32 D2 38.BIVW38ID2 44.BIW 441 10
14 ID1  2.       DI  8.    IC02 14.     IC02 20.     C02 26.DTOT26IC02 32.      D1 38.     ID1 44.     I 14
18 ID3  2.AI   2 D3  8.AI 8IC0314. AI 14IC03 20.AI 20 C03 26.AI 26IC03 32. At 32 D3 38.AI 38ID3 44.AI 441 18
22 I     .-- -- E1   8. -- --IC5D14. -- --IC5D 20.-- - - C5D 26.-- --IC5D 32.-- - - E1 38.-- --I  .-- --I 22
26 I      AW   2 E2  8.AW 8IC6D 14.AIVH14IC6D 20.AIVH20 C6D 26.AW 26IC6D 32.AW 32 E2 38.AW 371 .AW 441 26
30 I     .-- -- E3   8.-- --ID7 14.-- --167 20.-- - - D7 26.-- --ID7 32.-- - - E3 38.-- --I   .- --I 30
34 1      .     E4   8.    ID8 14.-- --ID8 20.-- - - De 26. C8D26ID8 32.      E4 38.     I    .     I 34
38 I      .     'ES  e.    IDS 14.      ID9 20.      D9 26. C9D26ID9 32.      E5 38.     I    .     I 38
42 ID2  3 BIW  3 ID2 9.BIW 9ID2 15.BIV 15ID2 21.BIV 21 D2 27.BIV 27ID2 33 BIV 33ID2 39.BIVW39ID2 45. BIW 451 42
46 ID1  3.       D1  9.    IC02 15.     IC02 21.AV 21 C02 27.AV 27IC02 33.    ID1 39.     ID1 45.      I 46
DO ID3  3 AI   3 D3  9.AI 9IC03 15. AI 15IC03 21.-- - - co3 27.-- --IC03 33 AI 33ID3 39.AI 39ID3 45.11 451 SD
94 I     .-- -- E6   9.-- --IC8D IS. -- --IC7D 21.-- - - C7D 27. -- --IC7D 33 - - --IE6 39.-- --I .-- --I 54
58 I     . WEFA I E7  S.    IC9D 15.    IC8D 21.-- - - C8D 27.-- --ICED 33.      IE7 39.     I    .    I 58

HH I   02 UT   I   05  UT  I   08  UT  I   11 UT   I   14    UT I   17 UT    I   20 UT    t   23   UT   I HH
MM I  CH1  CH2  CH1  .  CH2 I CH1 . CH2 I CH1 . CH2 t CH1 . CH2 I CH1   CH2  I CH1 . CH2 I CH1 . CH2 I MM
 2 I     .-- -- E8   9:     I    .WEFA 3tCSD 21.-- --IC9D 27.-- --IC9D 33:    IE8  39:     I         I  2
 6 I        IE9  9.      I  .-- --I     .-- --I     .-- --I    IE9  39.      I         I  6
10 ID2  4 BIW 4ID2 10.BIW 10ID2 16.BIVW16ID2 22.BIVW22ID2 28.BIVW28ID2 34 BIVW34ID2 40.BIW 40ID2 46 BIW 46I Ib
14 ID1  4 TEST 4 D1 10.ADMH 0IC02 16.TEST 0IC02 22.ADMH 0 C02 28.TEST 4IC02 34 ADMH 0ID1 40.TEST 0ID1 46.ADMH0I 14
ID ID3  4 at  4 D3 10.AI 10IC03 16. AI 16IC03 22.AI 22 C03 28.AI 28IC03 34 AI 34ID3 40.AI 40ID3 46.AI 461 18
22 ITEST B. -- -- ADMH 0.-- --ITEST 4. -- --IADMH 0.-- - - TEST 0.-- - - tADMH 0.-- --ITEST 4.-- --IADMH 0. -- --I 22
26 I     .          I    .    I    .          .WEFA 4I       I     .WEFA 61        t 26
30 I     .          I    .    I    .          .-- --I        I     .-- --I          I 30
34 IRANG 0.RANG 0 RANG 0.RANG 0IRANG 0: RANG 0IRANG 0.RANG 0 RANG 0.RANG 0IRANG 0. RANG 0IRANG 0.RANG 0IRANG 0. RANG 0I 30
38 IRANG 0.RANG 0 RANG 0.RANG 0IRANG 0.RANG 0IRANG 0.RANG  B RANG 0.RANG 0IRANG 0.RANG 0IRANG 0.RANG 0IRANG 0. RANG 0I 38
42 ID2  5.BIW 5 D2 11.BIW 11ID2 17.BIV 17ID2 23.BIV 23 D2 29.BIV 29ID2 35 BIV 35ID2 41.BIW 41ID2 47.BIW 47I 42
46 ID1  5.     ID1  II.   IC02 17.   IC02 23.AV 23 CO2 29.     ID1 3s.     ID1 41.     ID1 47.      I 46
50 ID3  5.AI 5ID3 11.AI 11IC03 17.AI 17IC03 23. -- --IC03 29.AI 29ID3 35 AI 35ID3 41.AI 41ID3 47.AI 47I 50
54 I    .-- --IE1 11.-- --ITEST 4. -- --IE1 22.-- --J    . -- --IE1 34.-- - - I    .-- --IE1 47.-- --I 54
set     .CTH 0IE2 11.     ITEST 4.CTH 0IE2 22.-- --I    .CTH 0IE2 34.      I    .CTH 0IE2 47.     I 58
```

SOME FORMATS ARE SUBJECT TO '. DUE TO SEASONAL UHDERJ' 'MINATION

FIGURE 24 Example of the METEOSAT Dissemination Schedule

For this reasdn users are advised that it is expedient to provide equipment capable of receiving both METEOSAT dissemination channels, either simultaneously or by switching between channels. To standardise the start times of individual formats, four minute transmission slots have been introduced. Formats start at the nominal time? H + 02, + 06, + 10 etc., with actual transmissions scheduled to start a few seconds after these nominal times. HR formats may use between 1 (BI) and 8 (AIV) slots. If a format is finished before the end of a dissemination slot the time period between end of this image and the start of the next image is not used on dissemination channel 2. Time slots between consecutive WEFAX transmissions on channel 1 are used for retransmission of DCP data.

METEOSAT Dissemination Schedules listing all disseminations for PDUS and SDUS users are produced by ESOC and can be mailed to all interested persons or organisations on request. An example of this schedule is shown in Fig. 24.

6.1 Key to the METEOSAT Dissemination Schedule

<u>Heading</u> The schedule number is generated with the following design:

YYMMC/NN

Y Y = Year of introduction

MM = Month of introduction

C = Character which indicates the satellite

N N = Number of schedule introduced in this month

The schedule number is important since changes to schedules will be announced by administrative messages. The information "valid from" is important as schedules are normally distributed in advance.

COLUMN HEADINGS - CH1 is the METEOSAT dissemination channel at 1694.5 MHz
CH2 is the METEOSAT dissemination channel at 1691.0 MHz
The time HH is the HOUR during which transmission starts

ROW HEADINGS - MM gives the minute of the hour for the start of the transmission

TABLE ENTRIES - give the FORMAT
- followed by the slot number of the image used. The slot number is effectively the nearest half hour at the end of the image, e.g., image ending near to
1200 UT = slot 24
Image ending near to
1930 UT = slot 39
The actual end time of the image is part of the header in all digital image transmissions

FORMATS The formats are indicated with the characters used in the format description (3.3 and 3.4). Formats generated at CMS-Lannion are

FORMATS indicated by an "L". The numbers following the indicating character define the area of the format (as shown in figures). Slots with the entry RANG are allocated to spacecraft ranging. During these slots no dissemination is scheduled.

Examples: AIV 18 = Infrared plus visible image of the globe as seen by METEOSAT. Slot 18 (canpletion time = 0900 GMT) is used.

LX 24 = Visible and infrared image of X-sector as seen by GOES-E spacecraft. The image is formatted in CMS-Lannion and is taken from slot 24 (completion time near to 1200 GMT).

6.2 Timing of High-Resolution Disseminations

BR-Formats are transmitted with the following frequencies:

A every hour (in IR)
B every 1/2 hour
X every 6 hours

In case of B-formats all available spectra with meaningful information for the particular slot are used. That means that format BIW is transmitted during night times, BIV or BIVW are transmitted when illumination in the visible spectrum is sufficient.

A-Formats are mainly used as AI or AW. Format AV is scheduled once or twice only due to the long transmission time. The interleaved formats AIV and AIVW are not used at the present time. Format AIVH will after a test period be transmitted hourly replacing AI formats (day time only).

7. TECHNICAL SPECIFICATIONS OF PDUS EQUIPMENT

A PDUS is comprised of the following two sub-systems:

- Ground Station
- Image Handling System

7.1 Ground Station

The Ground Station consists of:

a)
- Antenna
- Low Noise Amplifier (Preamplifier)
- Downconverter

b)
- Receiver
- Demodulator

c)
- Bit Synchronizer
- Frame Synchronizer

7.2. Image Handling System

The Image Handling System varies very much according to the specifications of the user. It consists of:

- Computer
- Store Unit

Possible options are:

- Colour Image Display
- 'High-Resolution Recorder (Hardcopy system)
- Computer with external links for proceesed data and reformatted image information
- Video Recorder

7.3 System Description

The antenna must be suitable for operation in the 1.7 GHz band. A front-fed parabolic reflector with a 4,5m diameter is recommended. The receiver consists of the low noise front-end, one or more down-converter8 and the demodulator. The selection of the input frequency of the receiver has to be done by the user. Normally a frequency of approximately 70 MHz is chosen. Due to the fact that HR-Disseminations may be operated in both dissemination channels' two switchable Input frequencies have to be foreseen. The recommended bandwidth of the receiver is 1 MHz. The demodulator output will be a PCM signal with a bit rate of 166.66 kbit/sec.

Bit Synchronizers with bit rates from 100 bps to.5 M bpe and Frame Synchronizers with wordlengths of 8 to 24 bit8 and frame length of 4 to 256 words are offered by different manufacturers as standard equipment. The selection of word length depends on the computer ueed.

Suitable store media of PDUS image handling systems are either digital tape deck8 or Winchester disks. A minimum of 80 M byte disc store is recommended.

7.4. Input/Output Specifications

7.4.1 Spacecraft output data

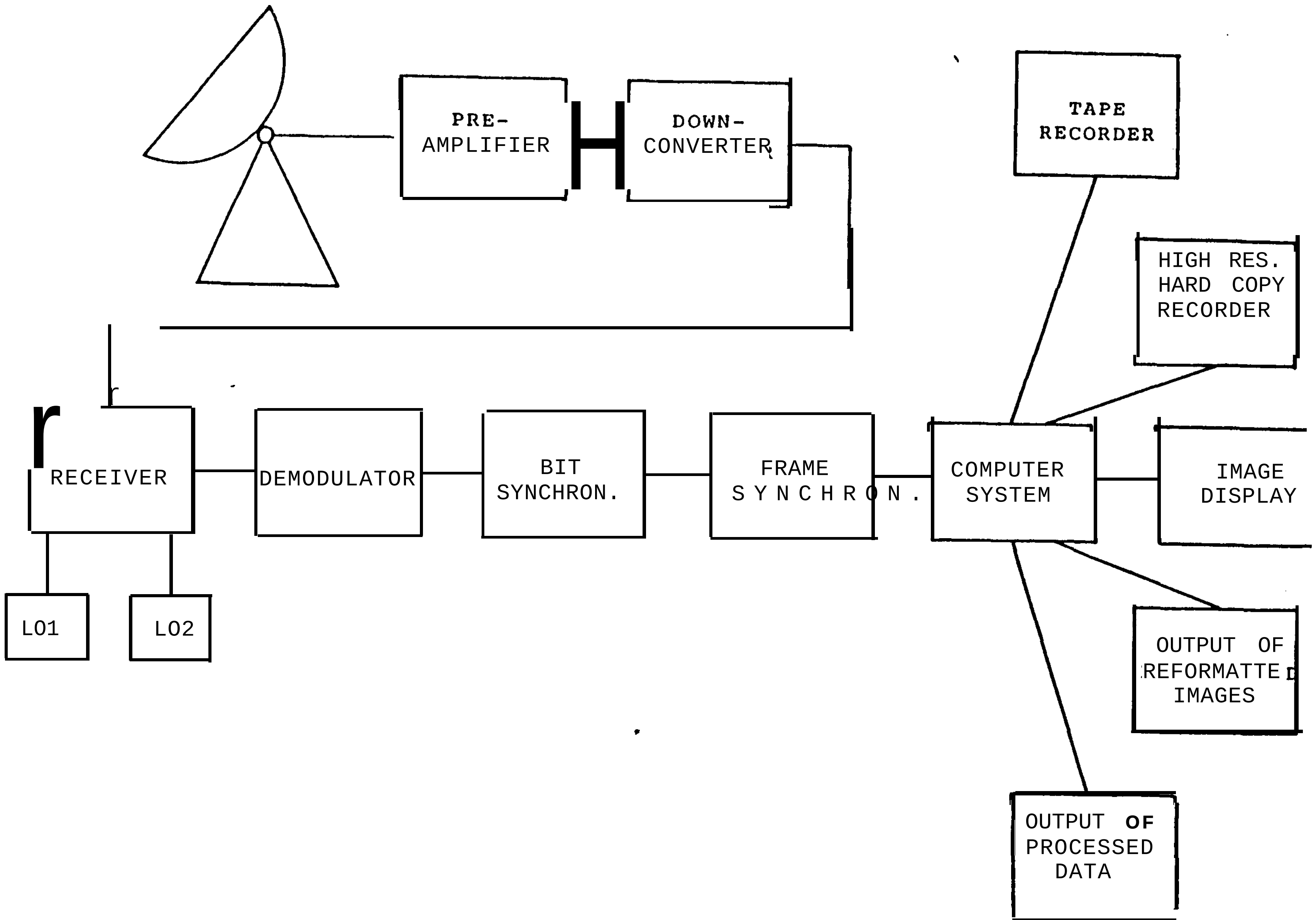
RF carrier frequency
- Channel 1 : 1694.50 MHz
- Channel 2 : 1691.00 MHz

7.4.2 PDUS front-end specification

The recommended C/T ratio for a PDUS 10.5 dB/°K. Depending on the location, however, a relaxation of this specification is possible. To gain this G/T ratio different system concepts are possible. The usage of a high quality antenna system with a diameter of approximately 4.5 m (antenna gain > 33 dB) allows the use of a low cost transistor preamplifier with a noise figure of approximately 200°K. A smaller antenna system could, on the other hand, be compensated by using a high quality parametric preamplifier with a noise figure ≈ 100°K.

Because of the different specifications for a PDUS by different users and the possible locations of the. station, further technical data for the PDUS are not given In this document, but advice can be obtained from the Agency.

A study for a 'low cost PDUS has been produced for ESA by the University of Dundee. A copy of the study can be obtained from the Agency.



FIG, 25 **PDUS BLOCK DIAGRAM**

7.4.3 Modulation Specifications

Modulation	PCM (SP-L)/PM
Index	1.2 rad ± 5%
Bit rate	166.66 kbit/sec
RF/F	660 Hz
min. signal to noise ratio	
C/No for receiver	-67.0 dB.Hz

METEOSAT HIGH RESOLUTION IMAGE DISSEMINATION

October 1989

Meteosat Exploitation Project

European Space Operations Centre
Robert-Bosch-Strasse 5
6100 Darmstadt
Federal Republic of Germany

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Preface

The aim of this document is to provide the information required to design and operate a Primary Data User Station (PDUS) and thereby receive and process METEOSAT High Resolution Dissemination formats.

High resolution digital data are designed to be primarily a high quality service for the EUMETSAT Meteorological Services, which fund the METEOSAT System. Readers should note that technical control of these data is currently being considered in order to ensure a proper data access in accordance with EUMETSAT's data policy.

This document has been established by the METEOSAT Exploitation Project in the European Space Operations Centre (ESOC), Darmstadt, Federal Republic of Germany, on behalf of EUMETSAT, the European organisation for the exploitation of meteorological satellites based also in Darmstadt, Federal Republic of Germany. ESOC is part of the European Space Agency (ESA), Paris, France, which operates the METEOSAT Operational Programme on behalf of EUMETSAT.

1.0 INTRODUCTION

METEOSAT dissemination is the process whereby image data and some other meteorological information are relayed via the spacecraft to the user community (see Figure 1).

The spacecraft has two dedicated dissemination channels operating in S-band at 1691.0 MHz and 1694.5 MHz. Two forms of transmission are employed; conventional analogue transmissions (WEFAX), and digital transmissions (HR = High Resolution). The WEFAX transmissions are in the APT (Automatic Picture Transmission) format and are intended for users who wish to use the data in a subjective manner. Information about this type of transmission can be obtained from the document entitled "METEOSAT WEFAX Transmissions". The HR digital data are in a format specific to METEOSAT and are designed for users requiring data with the full radiometric and spatial resolution in a form suitable for further local data processing.

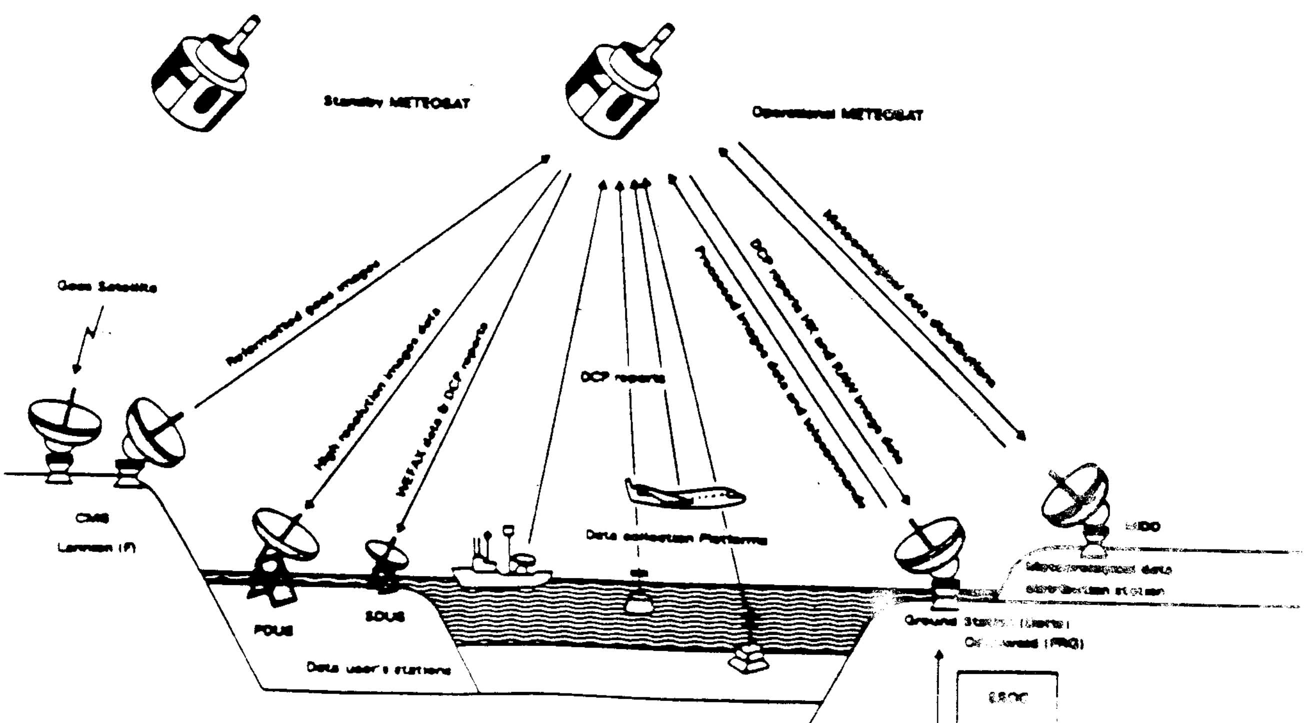

Figure 1. The METEOSAT Missions.

2.0 PRIMARY DATA USER STATIONS (PDUS)

METEOSAT High Resolution (HR) transmissions can be received by Primary Data User Stations (PDUS). Technical specifications and recommendations for the construction of a PDUS are provided in a later section of this document, however, in its simplest form a PDUS will comprise of:

- parabolic antenna;
- low noise amplifier;
- down converter;
- receiver with demodulator;
- bit- and frame-synchronisers;
- image processor.

The images distributed via HR-dissemination have the full resolution of the original image and are therefore eminently suitable for further quantitative processing. The complexity of the image handling system will be dependent on the level of processing envisaged by the user. Typical processing may include remapping of images to different projections, derivation of meteorological products for local areas and the merging of image data with that from other sources, e.g. radar data, conventional meteorological data, forecasts and analyses. It is also probable that a high resolution hard copy device and/or a colour display would be required.

These suggestions only provide an indication of the type of processing which may be performed on HR-dissemination formats. The cost of a PDUS station, beyond the essential elements of the ground receiving station, will mainly depend on the complexity of the image handling system

3.0 IMAGE DATA

The images disseminated in the form of HR-formats originate from two different sources: METEOSAT and the GOES-E spacecraft.

3.1 METEOSAT

METEOSAT takes images in three spectral bands:

0.5 - 0.9µm	- visible band;
5.7 - 7.1µm	- infrared water vapour absorption band;
10.5 - 12.5µm	- thermal infrared (window) band.

The infrared and water vapour images are composed of 2500 lines, each of 2500 pixels, whilst the visible image consists of 5000 lines of 5000 pixels. The corresponding spatial resolutions at the sub-satellite point are 5 km and 2.5 km, respectively. Scanning of the Earth nominally takes place every half-an-hour, providing images in all three spectral channels. Data from all spectral channels are coded in eight bits corresponding to 256 grey levels (0 - 255).

3.2 GOES-E

The GOES-E spacecraft is nominally located in geostationary orbit at 75 W, however, when only one GOES spacecraft is operational it may be moved to a more westerly location. Images are disseminated from the following spectral bands:

0.55 - 0.75µm	visible channel;
10.50 - 12.60µm	infrared channel.

The instrument on board GOES is known as the Visible and Infrared Spin Scan Radiometer (VISSR). The imager scans one infrared line for each spin of the satellite, providing approximately 7 km resolution at the subsatellite point. In the visible channel eight lines are scanned simultaneously giving a maximum resolution of about 1 km at the sub-satellite point, however, visible channel data disseminated through METEOSAT has the scan lines combined in groups of two giving an approximately 2 km resolution.

4.0 HIGH RESOLUTION FORMATS

METEOSAT HR-formats originate from the European Space Operations Centre (ESOC) located in Darmstadt, Federal Republic of Germany, while those from GOES-E are received, reformatted and transmitted to METEOSAT for dissemination by the Centre de Météorologie Spatiale in Lannion, France. Formats from both centres are transmitted in the same mode and the transmission speed is 166.66 kbits/s.

4.1 HR-formats originating from ESOC

All raw image data received at the computer processing centre in ESOC are pre-processed e.g. to correct for registration errors caused by the different fields of view of the detectors. In addition, to compensate for the motion of the satellite, geometrical processing is performed. This means that for the user the images always appear to be taken from ~~a satellite at~~ its nominal location, i.e. the received image is located to a fixed reference frame. The end result of geometrical processing is known as a rectified image and has the advantage that, when images are replayed in an animation sequence, there is no discernible movement of geographical features. Space view data are artificially set to the value 0.

The geometrical image processing is based on an image geometry model which derives its inputs from horizon detection on the infrared image and results in a very accurate fine attitude determination. The rectification of the current image is calculated from the deformation vector field obtained from the geometry model of the current image. This image geometry model is updated dynamically and describes the movement of an image related reference frame as a function of radiometer scan step. This allows the calculation of a deformation vector for every image point on the Earth.

4.1.1 Visible channel data in A- and B-formats

In the A- and B-formats the VIS channel data is indicated as coming from the "southern" (VISs) or "northern" (VISn) detector. This means that during the scanning of the Earth the VISs detector scans the line immediately to the south of the VISn detector, in terms of geographical coordinates. The nominal modes of operation of the visible detectors are VIS1 plus VIS2, with VIS3 plus VIS4 as back-up, however, other combinations are possible, e.g. VIS2 plus VIS4, in the case where one of the detectors in the nominal pairs is defective.

If the required visible channel is not active (e.g. due to a spacecraft failure) the dissemination software uses the following rules:

- If one visible channel (south or north) is required, and data for only one visible channel are available, then use that data even if it is not that for the required channel.
- If two visible channels are required, and data for only one visible channel is available, then duplicate the data for that channel.

4.1.2 A-format

The A-format represents the whole earth disk as seen by METEOSAT's visible, infrared and water vapour detectors (Figures 4 and 5). The image information of one or more detectors can be transmitted in a given format. All possible combinations of A-formats are given in Table 1.

Format	VIS	IR	WV	Transmission time (min)
AV	VISs (2500 lines * 5000 pixels) + VISn (2500 lines * 5000 pixels)	-	-	23.5
AI	-	2500 lines * 2500 pixels	-	6
AW	-	-	2500 lines * 2500 pixels	6
AIV	as AV	as AI	-	29.3
AIW	-	as AI	as AW	11.8
AIVW	VISn (2500 lines * 5000 pixels)	as AI	as AW	23.5
AIVH	VISs (2500 lines * 2500 pixels) (Data reduction by taking only each second pixel within the line)	as AI	-	11.8

Table 1. Possible A-format combinations.

With the exception of the AIVH format, all images have the same resolution as the raw image. The A-format consists of 5000 lines of 5000 pixels in the visible channel and 2500 lines of 2500 pixels in the infrared and water vapour channels. In the AIVH formats the visible channel data is reduced to the resolution of the infrared and water vapour channels by only using data from one visible channel and sampling every second pixel in a line

4.1.3 B-format

The B-format covers the European, North African and Middle East regions and may contain information from one or more of METEOSAT's detectors. Table 2 shows all possible B-formats which could be produced and Figures 2 and 6 indicate the geographical area covered by the B-format.

Format	VIS	IR	WV	Transmission time (min)
BV	VISs (625 lines * 2500 pixels) + VISn (625 lines * 2500 pixels)	-	-	3.1
BI	-	625 lines * 1250 pixels	-	0.9
BW	-	-	625 lines * 1250 pixels	0.9
BIV	as BV	as BI	-	3.8
BIW	-	as BI	as BW	1.6
BIVW	VISn (625 lines * 2500 pixels)	as BI	as BW	3.1

Table 2. Possible B-format combinations.

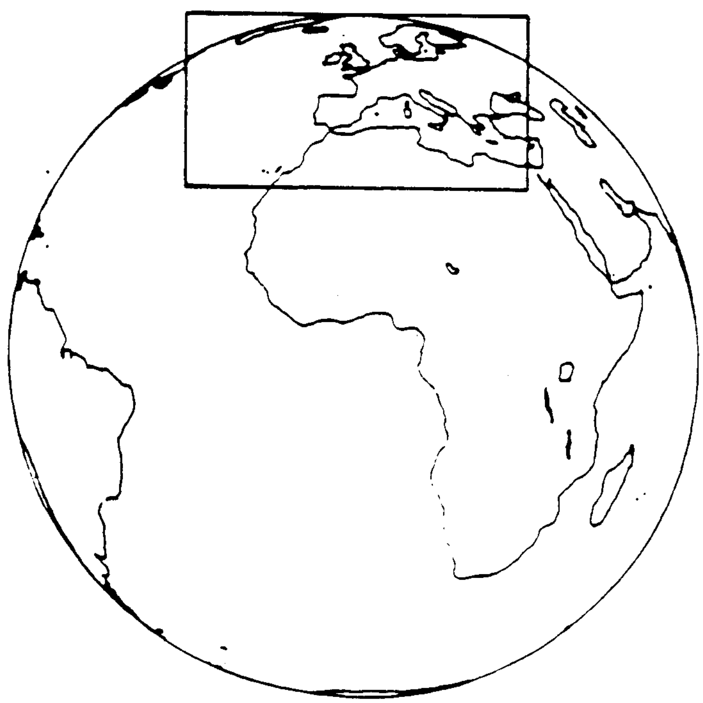

Figure 2. The B-format.

METEOSAT scans the Earth from south to north and from east to west. The starting line of B-formats is 1810, the last line is 2434. For the IR and WV formats the first pixel in a line is 626, the last 1875. The first pixel within a visible line is 1252 and the last 3751.

4.2 HR-formats originating from CMS-Lannion

4.2.1 X-format

The X-format covers the North and South American continents and contains infrared, or a combination of visible and infrared, image data from the NOAA GOES-E satellite. The X-format consists of 2500 lines of 2500 pixels in the visible channel and 1250 lines of 1250 pixels in the infrared channel. The resulting resolutions at the sub-satellite point are 2 km for the visible channel data and 7km for the infrared data. The transmission of an XI-format takes place during one dissemination time slot (4 minutes), the XIV-format during two dissemination time slots. The area of an X-format is indicated in Figure 3.

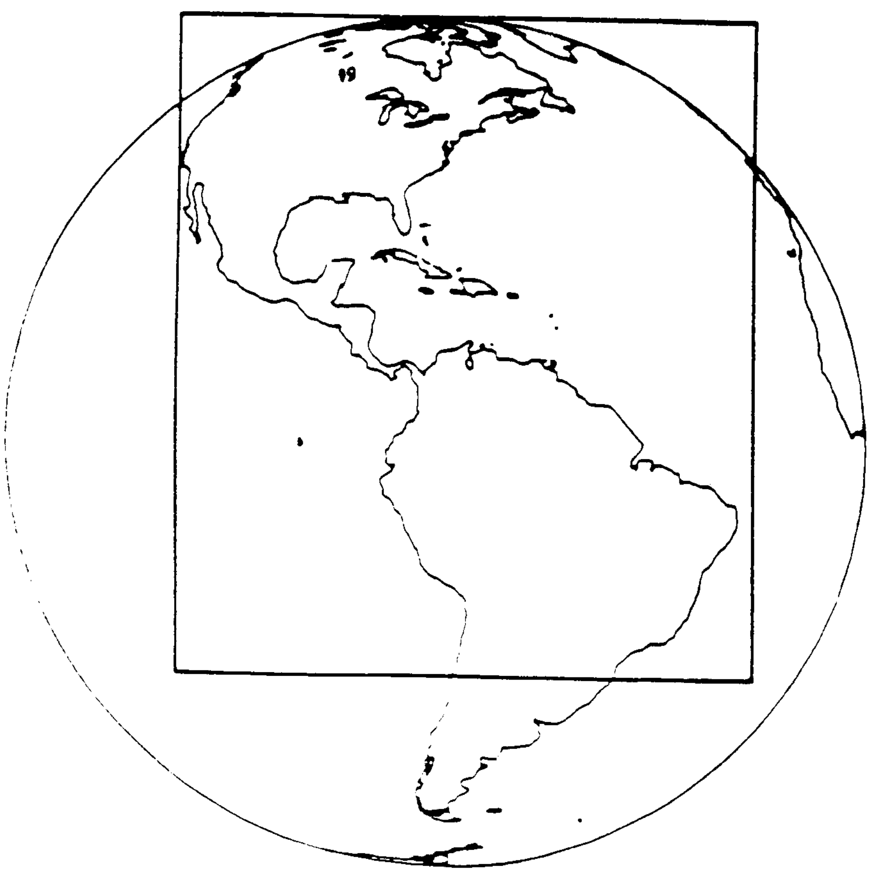

Figure 3. The X-format.

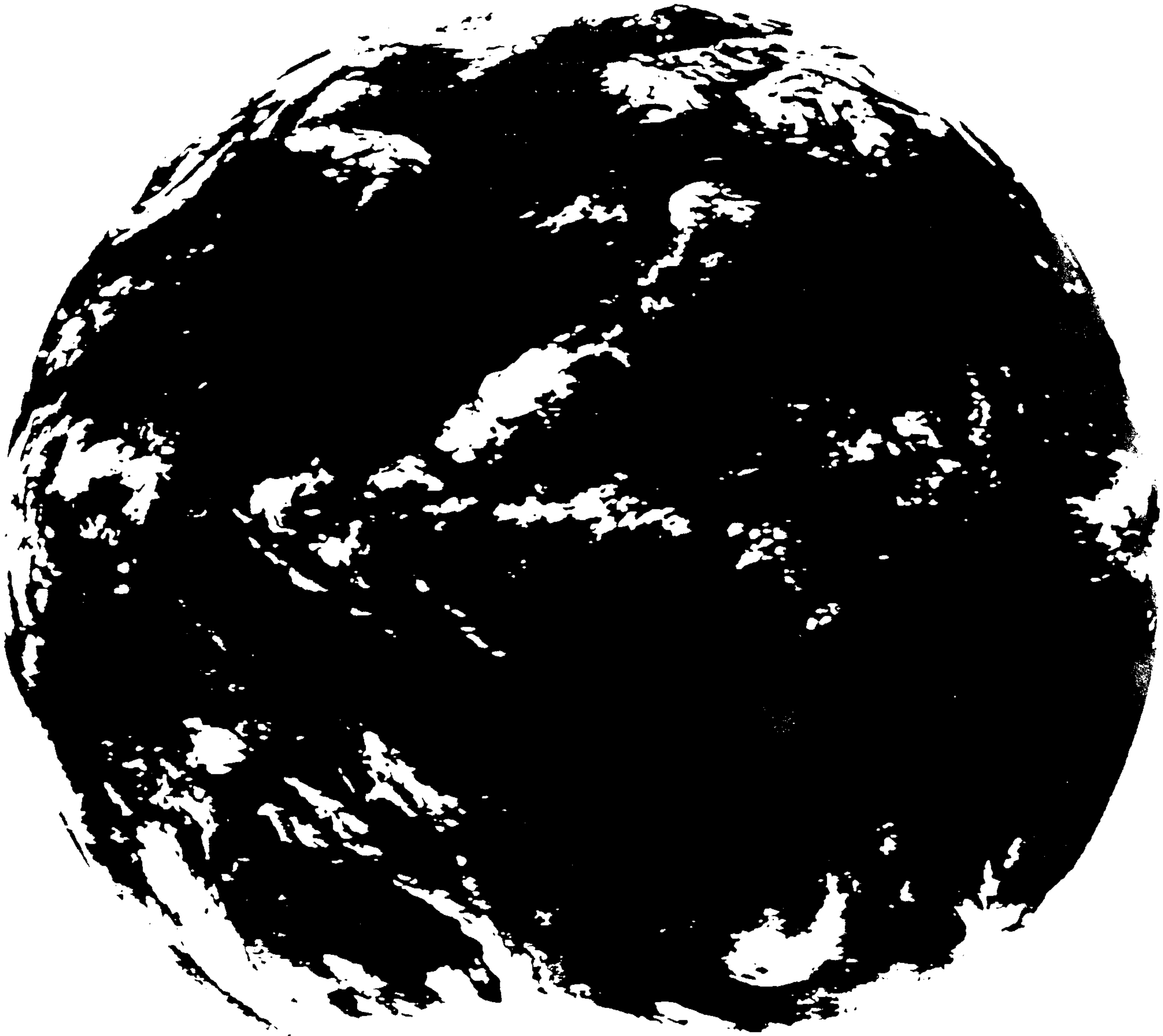

Figure 4. The area of the A-format (infrared).

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Figure 5. The area of the A-format (water vapour).

Figure 6. The area of the B-format (visible).

5.0 DIGITAL TRANSMISSION FORMATS

5.1 Definition of terms

Formats are structured into subframes and frames; the following definitions apply:

FORMAT:

Data set used for the transmission of image information, e.g.

```
A-formats:  AV, AI, AIVW . .     . . .
B-formats:  BV, BI, BIVW . . . . . . .
X-formats:  XI, XV, XIV  . .     . . .
```

FRAMES:

Each data frame consists of 364 words of 8 bits.

SUBFRAMES:

An A-format subframe consists of 8 frames whilst B- and X-format subframes consist of 4 frames.

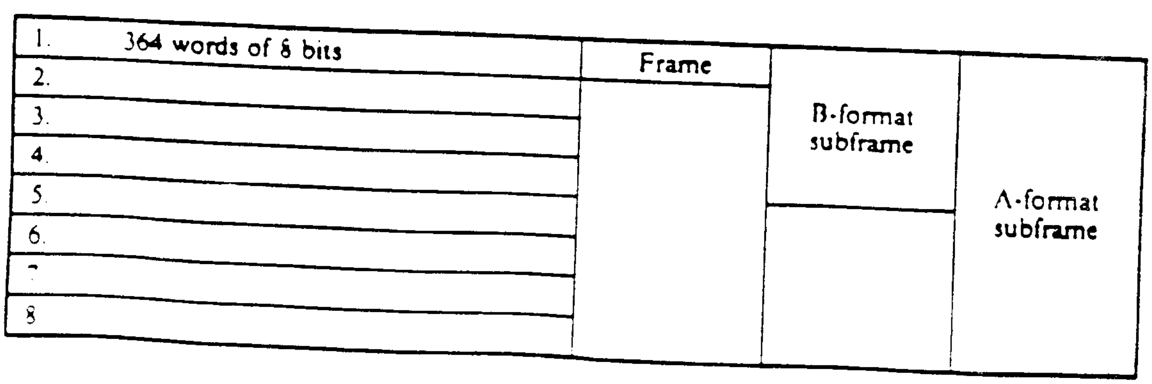

Figure 7. Representation of the frame/subframe relationship.

5.2 *Format construction*

A complete format consists of the following sets of subframes:

1. Heading subframes;
2. Image data and grid information subframes;
3. Conclusion subframes.

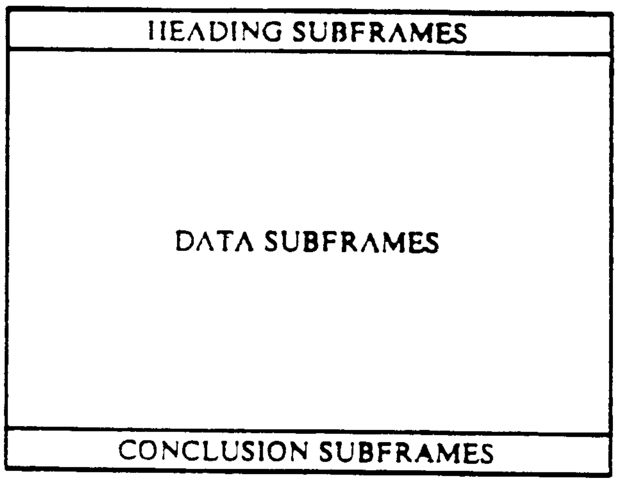

Figure 8. Format construction.

5.3 *Elements of subframes*

Before explaining the construction of subframes in detail it is first necessary to describe the other data fields within the subframes. These data fields are:

- Synchronisation Word;
- ID-Word;
- Label;
- Identification;
- Interpretation Data.
- Fillers: SP1, SP2, SP4, SP5 and SP6.
- Grid Information.

5.3.1 Synchronisation Word

Each frame starts with a synchronisation word. This word is identical in all frames and all subframes. It consists of the following three bytes:

```
(MSB) 00000101 00001100 11011111 (LSB)

      MSB = Most Significant Bit;
      LSB = Least Significant Bit.
```

5.3.2 ID-Word

The ID-word is the fourth byte of each frame. It consists of 8 bits and the value of the ID-word is increased by 1 for each frame within a subframe. The first ID-word of the first frame in each A-format subframe is:

```
(MSB) 01110000
```

Since A-format subframes consist of 8 frames the ID-word of the last frame in each A-format subframe is:

```
(MSB) 01110111
```

The ID-word of the first frame in each B-format and X-format is:

```
(MSB) 00110000
```

Since the B- and X-format subframes consist of 4 frames, the ID-word of the last frame in each B- or X-format subframe is:

```
(MSB) 00110011
```

By interpreting the ID-word it is possible to distinguish between A- and B- or X-formats. The difference between them is in bit 2 of the ID-word which is

```
1 for A-formats
and
0 for B- and X-formats
```

5.3.3 Label

The label consists of 24 bytes and is present in the first frame of each subframe. The contents of the label are as follows:

Byte	*Description*
1 + 2	Number of frames in the subframe: 8 for A-formats, 4 for B- and X-formats.
3 + 4	Total number of subframes in the format counting the 42, 84 or 90 header subframes as 1 and all conclusion subframes as 1. (The total number of subframes is therefore 2 plus the number of data subframes).
5 + 6	Current subframe number. For all header and conclusion subframes the current subframe number is 1. The counting of data subframes starts with 0 for the first data subframe.
7 + 8	Image line number. This is zero in the header and conclusion subframes. In A- and X-formats the first image line number is 1 and in B-formats is 1810. In all cases the image line number increases by 1 for each set of subframes that corresponds to a single line.
9 - 12	Image number from the start of the mission.
★ 13	Format indicator (hexadecimal); A = 00, B = FF, X = 0F.
14 to 17	Indicators of spectral information in the subframe.

```
Byte 14 = VISs.
Byte 15 = VISn.
Byte 16 = IR.
Byte 17 = WV.
```

These indicators are set to the following hexadecimal values:

```
00 if corresponding data are not represented in the subframe
FF if corresponding data are represented in the subframe.
```

Since subframes containing full resolution VIS information contain only half lines. bytes 14 and/or 15 are used in data subframes as follows

```
F0 if 1st half of VIS line is present in the data subframe.
0F if 2nd half of VIS line is present in the data subframe.
```

In data frames containing reduced VIS information (AIVH-format) bytes 14 or 15 are set to FF.

18 Indicator of grid information:

```
00 if no grid information is present.
0F if reference grid information is present.
```

19 Spare bytes, set to 00.

20 Indication of scan direction.

```
00 if scan is S-N and E-W.
F0 if scan is N-S and E-W.
0F if scan is S-N and W-E.
FF if scan is N-S and W-E.
```

Normally byte 20 has the hexadecimal value 00

21 - 24 Spare bytes, set to 00.

5.3.4 Identification

The identification field is present in the first frame of all heading and conclusion subframes.

Byte	*Description*
1 ÷ 2	Satellite indicator. The origin of the image data contained in the transmitted format is given by the satellite indicator.

```
GOES         =  0000 (hexadecimal)
METEOSAT 1   =  D4E3  =  MT (EBCDIC CODE)
METEOSAT 2   =  D4F2  =  M2 (  ..      .. )
METEOSAT n   =  D4Fn  =  Mn (  ..      .. )
```

3 ÷ 4	Year of image acquisition (e.g. 1989) coded as a binary value.
5 ÷ 6	Day of year (e.g. 346) of image aquisition coded as a binary value.

7 + 8 Nominal image time. This information is coded in binary (BCD - Binary Coded Decimal) and indicates hour and minute of completion of image acquisition e.g. 0100 (slot 02), 1430 (slot 29).

9 - 20 As for the label in header subframes

21 - 32 Spare bytes, set to 00.

5.3.5 Interpretation Data

The Interpretation Data block is present in the first four frames of each header and conclusion subframe. It consists of 1360 bytes and provides information on calibration, satellite orbit, geographical correction parameters and administrative messages. A full description of the Interpretation Data block is given in Section 7

5.3.6 Fillers

Fillers are included in the data transmission in order to keep subframes to a fixed structure. They are as follows:

```
SP1 = 8 bytes, all set to 00.
SP2 = 16 bytes, all set to 00.
SP4 = 360 spare bytes, all set to 00.
SP5 = 40 bytes, all set to 00.
SP6 = 8 bytes, all set to 00.
```

5.3.7 Grid Information

Grid information is enclosed in each data subframe. The n^{th} bit of the grid information corresponds to the n^{th} byte of the image data of the same data subframe. The bit is set to 1 if grid point data is available.

The grid information of A-formats consists of 316 bytes (2528 bits). The first 2500 bits are the grid information corresponding to 2500 image pixels within the subframe. 28 spare bits are set to 0

The grid information of B- or X-formats consists of 158 bytes (1264 bits). The first 1250 bits represent the grid information corresponding to the 1250 image pixels transmitted within the subframe. 14 spare bits are set to 0.

5.4 *Construction of subframes*

5.4.1 Heading subframes

5.4.1.1 Heading subframes of A-formats

The heading subframes of A-formats consist of 8 frames of 364 bytes each. The structure is as follows.

---------------------------- 364 bytes ----------------------------

SYNC 3	ID 1	LABEL 24	SP1 8	IDENTIFICATION 32	SP2 16	INTERPRETATION DATA (280 bytes)
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	SP4 (BLANK FILL)				
SYNC	ID	SP4				
SYNC	ID	SP4				
SYNC	ID	SP4				

= 364

Figure 9. Heading subframe of the A-formats.

The heading subframe is transmitted 42 times for each A-format.

5.4.1.2 Heading subframes of B- and X-formats

The heading subframes of B- and X-formats consist of 4 frames each of 364 bytes. The structure is as follows:

---------------------------- 364 bytes ----------------------------

SYNC 3	ID 1	LABEL 24	SP1 8	IDENTIFICATION 32	SP2 16	INTERPRETATION DATA (280 bytes)
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	INTERPRETATION DATA (360 bytes)				
SYNC	ID	INTERPRETATION DATA (360 bytes)				

= 364

Figure 10. Heading subframe of B- and X-formats.

The heading subframe is transmitted 84 times for B-formats and 90 times for X-formats.

5.4.2 Data subframes

5.4.2.1 A-format data subframes

A-format data subframes consist of 8 frames of 364 bytes each. The structure is as follows:

---------------------------- 364 bytes --------------------------------

SYNC	ID	LABEL	SP5	DATA (296 bytes)
SYNC	ID	DATA (360 bytes)		
SYNC	ID	DATA (360 bytes)		
SYNC	ID	DATA (360 bytes)		
SYNC	ID	DATA (360 bytes)		
SYNC	ID	DATA (360 bytes)		
SYNC	ID	DATA (360 bytes)		
SYNC	ID	DATA (44 bytes)		(316 bytes) GRID

Figure 11. The A-format data subframe.

Each A-format data subframe includes 2500 bytes of image information. This corresponds to 2500 image pixels and represents either one complete line of an IR or WV image or half a line of the image from one VIS channel (in the AIV11 format the VIS channel data is from one line but only every other pixel).

5.4.2.2 B- and X-format data subframes

B- and X-format data subframes consist of 4 frames of 364 bytes each.

The structure is as follows:

---------------------------- 364 bytes --------------------------------

SYNC	ID	LABEL	SP6	DATA (328 bytes)
SYNC	ID	DATA (360 bytes)		
SYNC	ID	DATA (360 bytes)		
SYNC	ID	DATA (202 bytes)		(158 bytes) GRID

Figure 12. The B- and X-format data subframe.

Each B-format data subframe includes 1250 bytes of image information. This corresponds to 1250 image pixels and represents one complete B-format line of an IR or WV image or half a B-format line of an image from one VIS channel.

5.4.3 Conclusion subframes

The conclusion subframe is a copy of the heading subframe. The number of conclusion subframes transmitted is:

1	for all A-formats
	for BI, BIV, BW, BVW and X-formats;
2	for BIW, BIVW and BV.

5.5 *Sets of data subframes*

A set of data subframes represents one image line of all spectral channels included in the individual transmission format. A set of data subframes therefore consists of one or a combination of the following elements:

- one subframe of IR data;
- two subframes of VISs data;
- two subframes of VISn data;
- one subframe of WV data.

Consequently, the number of data subframes in a set of subframes varies in accordance with the number of spectral channels for which information is included in the transmission format. The formats include the following information:

AI, BI, XI	subframe	IR only
AIV, BIV	subframes	IR + VISs + VISn
AIW, BIW	subframes	IR + WV
AIVW, BIVW	subframes	IR + WV + VISs
AW, BW	subframe	WV only
AV, BV	subframes	VIS only (VISs + VISn)
AIVH	subframes	Reduced VISs + IR
XIV	subframes	IR + VIS

Within the sets of subframes the data subframes from the different spectral channels are transmitted in the sequence

IR, VISs, VISn, WV.

6.0 TRANSMISSION FORMATS

A list of available transmission formats is given in Sections 4.1.1 (A-formats), 4.1.2 (B-formats) and 4.2.1 (X-formats). Examples of the construction of some transmission formats are shown in the following figures. In the case where information from one visible channel is not available, the information from the other visible channel is repeated in formats AV, BV, AIV and BIV.

BI-format

Heading sub-frames	IR line 1810	IR line 1811	IR line 1812	IR line 1813	IR line 1814	IR line 1815	IR line 1816	IR line 1817	IR line 1818		IR line 2429	IR line 2430	IR line 2431	IR line 2432	IR line 2433	IR line 2434	Conclusion
84SF = 336F	625 subframes = 2500 frames																1SF = 4F

BV-format

Heading sub-frames	VISs 1/2 line 1810	VISs 1/2 line 1810	VISn 1/2 line 1810	VISn 1/2 line 1810	VISs 1/2 line 1811	VISs 1/2 line 1811	VISn 1/2 line 1811	VISn 1/2 line 1811	VISs 1/2 line 1812		VISn 1/2 line 2433	VISn 1/2 line 2433	VISs 1/2 line 2434	VISs 1/2 line 2434	VISn 1/2 line 2434	VISn 1/2 line 2434	Conclusion
84SF = 336F	2500 subframes = 10000 frames																2SF = 8F

BW-format

Heading sub-frames	WV line 1810	WV line 1811	WV line 1812	WV line 1813	WV line 1814	WV line 1815	WV line 1816	WV line 1817	WV line 1818		WV line 2429	WV line 2430	WV line 2431	WV line 2432	WV line 2433	WV line 2434	Conclusion
84SF = 336F	625 subframes = 2500 frames																1SF = 4F

Figure 13. Structure of the BI, BV, BW formats.

BIW format

Heading sub-frames	IR line 1810	WV line 1810	IR line 1811	WV line 1811	IR line 1812	WV line 1812	IR line 1813	WV line 1813	IR line 1814		IR line 2432	WV line 2432	IR line 2433	WV line 2433	IR line 2434	WV line 2434	Conclusion
84SF = 336F	1250 subframes = 5000 frames																2SF = 8F

BIVW-format

Heading sub-frames	IR line 1810	VISn 1/2 line 1810	VISn 1/2 line 1810	WV line 1810	IR line 1811	VISn 1/2 line 1811	VISn 1/2 line 1811	WV line 1811	IR line 1812		VISn 1/2 line 2433	WV line 2433	IR line 2434	VISn 1/2 line 2434	VISn 1/2 line 2434	WV line 2434	Conclusion
84SF = 336F	2500 subframes = 10000 frames																2SF = 8F

BIV-format

Heading sub-frames	IR line 1810	VISs 1/2 line 1810	VISs 1/2 line 1810	VISn 1/2 line 1810	VISn 1/2 line 1810	IR line 1811	VISs 1/2 line 1811	VISs 1/2 line 1811	VISn 1/2 line 1811		VISn 1/2 line 2433	IR line 2434	VISs 1/2 line 2434	VISs 1/2 line 2434	VISn 1/2 line 2434	VISn 1/2 line 2434	Conclusion
84SF = 336F	3125 subframes = 12500 frames																2SF = 8F

Figure 14. Structure of the BIW, BIVW, BIV formats

AI-format

Heading sub-frames	IR line 1	IR line 2	IR line 3	IR line 4	IR line 5	IR line 6	IR line 7	IR line 8	IR line 9		IR line 2495	IR line 2496	IR line 2497	IR line 2498	IR line 2499	IR line 2500	Conclusion
42SF = 336F	2500 subframes = 20000 frames																1SF = 8F

AV-format

Heading sub-frames	VISs 1/2 line 1	VISs 1/2 line 1	VISn 1/2 line 1	VISn 1/2 line 1	VISs 1/2 line 2	VISs 1/2 line 2	VISn 1/2 line 2	VISn 1/2 line 2	VISs 1/2 line 3		VISn 1/2 line 2499	VISn 1/2 line 2499	VISs 1/2 line 2500	VISs 1/2 line 2500	VISn 1/2 line 2500	VISn 1/2 line 2500	Conclusion
42SF = 336F	10000 subframes = 80000 frames																1SF = 8F

AW-format

Heading sub-frames	WV line 1	WV line 2	WV line 3	WV line 4	WV line 5	WV line 6	WV line 7	WV line 8	WV line 9		WV line 2495	WV line 2496	WV line 2497	WV line 2498	WV line 2499	WV line 2500	Conclusion
42SF = 336F	2500 subframes = 20000 frames																1SF = 8F

Figure 15. Structure of the AI, AV, AW formats.

AIVH-format

Heading sub-frames	IR line 1	VISsH line 1	IR line 2	VISsH line 2	IR line 3	VISsH line 3	IR line 4	VISsH line 4	IR line 5		IR line 2498	VISsH line 2498	IR line 2499	VISsH line 2499	IR line 2500	VISsH line 2500	Conclusion
42SF = 336F	5000 subframes = 40000 frames																1SF = 8F

AIVW-format

Heading sub-frames	IR line 1	VISn 1/2 line 1	VISn 1/2 line 1	WV line 1	IR line 2	VISn 1/2 line 2	VISn 1/2 line 2	WV line 2	IR line 3		VISn 1/2 line 2499	WV line 2499	IR line 2500	VISn 1/2 line 2500	VISn 1/2 line 2500	WV line 2500	Conclusion
42SF = 336F	10000 subframes = 80000 frames																1SF = 8F

AIW-format

Heading sub-frames	IR line 1	WV line 1	IR line 2	WV line 2	IR line 3	WV line 3	IR line 4	WV line 4	IR line 5		IR line 2498	WV line 2498	IR line 2499	WV line 2499	IR line 2500	WV line 2500	Conclusion
42SF = 336F	5000 subframes = 40000 frames																1SF = 8F

Figure 16. Structure of the AIVH, AIVW, AIW formats.

AIV-format

Heading sub-frames	IR line 1	VISs 1/2 line 1	VISs 1/2 line 1	VISn 1/2 line 1	VISn 1/2 line 1	IR line 2	VISs 1/2 line 2	VISs 1/2 line 2	VISn 1/2 line 2		VISn 1/2 line 2499	IR line 2500	VISs 1/2 line 2500	VISs 1/2 line 2500	VISn 1/2 line 2500	VISn 1/2 line 2500	Conclusion
42SF = 336F	12500 subframes = 100000 frames																1SF = 8F

Figure 17. Structure of the AIV format.

7.0 THE INTERPRETATION DATA BLOCK

The Interpretation Data block contains 1360 bytes and is organised in the following way:

1. Calibration Data (104 bytes);
2. Spacecraft Operations Data (128 bytes);
3. Imagery Data (328 bytes);
4. Administrative Message (800 bytes).

7.1 The Format of Integer, Logical and Real Values

Integer values (I*2, I*4)

Two-byte and four-byte integer values are represented as 16-bit and 32-bit binary numbers respectively. The first bit indicates the sign. A positive integer is represented by a 0 in the sign bit and a binary true number representation in the remaining bits. A two's complement with 1 in the sign bit represents a negative integer. All bits contain 0's to represent zero.

Logical values (L*1)

One-byte logical values are represented as 8-bit binary numbers. A true value has 1 in the least significant bit bit with all remaining bits set to 0. A false value has all bits set to 0.

Real values (R*4)

Real values are represented as 32-bit floating point numbers. The first bit indicates the sign. The seven bits following the sign bit indicate the exponent part. The mantissa consists of 24 bits following the exponent part, each four bits representing a hexadecimal digit. The hexadecimal radix point of the mantissa is to the left of the most significant mantissa digit. The exponent part is a number in the range 0 to 127. It represents an exponent in the range -64 to 63, after subtraction of 64 from the actual exponent

```
0        8         16        24       31
-------------------------------------
| S | E |              M             |
-------------------------------------
```

Double precision values (R*8)

Double precision values are represented as a 64-bit floating point number. Its sign and exponent part are similar to those described above. The mantissa consists of 56 bits following the exponent part and has 14 hexadecimal digits, each four bits representing a digit.

```
0        8         16        24        32        40        48        56       63
-------------------------------------------------------------------------------
| S | E |                              M                                      |
-------------------------------------------------------------------------------
```

S: sign (0 = positive, 1 = negative).

E: exponent (value obtained by adding 2^6 to the actual exponent).

M: hexadecimal mantissa part with the radix point to the left of bit 8.

Value = $\text{Man}.16^{exp}$.

7.2 Calibration Data

Offset	Name	Type	Length	Content
0	BBC1IR	ASCII	6	BB IR count for space view calibration XXX.XXX (XXXXXX is sent)
6	BBSD1I	ASCII	3	Standard deviation of BB IR count for space view calibration X.XX (XXX is sent)
9	BBC1WV	ASCII	6	BB WV count for space view calibration XXX.XXX (XXXXXX is sent)
15	BBSD1W	ASCII	3	Standard deviation of BB WV count for space view calibration X.XX (XXX is sent)
18	BB1T	ASCII	5	Temperature of 'cold' BB in K (only valid for nominal calibration mode) XXX.XX (XXXXX is sent)
23	BB2T	ASCII	5	Temperature of 'hot' BB in K in either space or nominal calibration mode XXX.XX (XXXXX is sent)
28	BBC2IR	ASCII	6	BB IR count for nominal calibration mode XXX.XXX (XXXXXX is sent)

Offset	Name	Type	Length	Content
34	BBSD2I	ASCII	3	Standard deviation of BB IR count for nominal calibration mode X.XX (XXX is sent)
37	BBC2WV	ASCII	6	BB WV count for nominal calibration mode XXX.XXX (XXXXXX is sent)
43	BBSD2W	ASCII	3	Standard deviation of BB WV count for nominal calibration mode X.XX (XXX is sent)
46	TIME1	ASCII	5	Timestamp for BB calibration DDDSS (DDD = day, SS = slot)
51	CALIR	ASCII	5	MIEC absolute IR calibration value 0.XXXXX (XXXXX is sent)
56	IRSPC	ASCII	3	IR space count XX.X (XXX is sent)
59	TIME2	ASCII	5	Timestamp for IR calibration DDDSS (DDD = day, SS = slot)
64	CALWV	ASCII	5	MIEC absolute WV calibration value 0.XXXXX (XXXXX is sent)
69	WVSPC	ASCII	3	WV space count XX.X (XXX is sent)
72	TIME3	ASCII	5	Timestamp for WV calibration DDDSS (DDD = day, SS = slot)
77			15	Spares
92	GAINS	ASCII	8	Gains for IR, WV, VIS1 or VIS4, VIS2 or VIS3, GiGiGwGwGvGvG2G2 (Gains are in the range 00-15)
100			4	Spares

Table 3. Interpretation data block: calibration section.

7.2.1 Description of parameters in the Calibration Section

There exist two different methods of performing a black body calibration on board the MOP series of satellites. They are termed 'nominal' calibration and 'space' calibration respectively.

Nominal calibration mode

Two black bodies exist on board the spacecraft, the first is known as the 'cold' black body and will assume the ambient temperature of that part of the radiometer in which it is located. The second black body, known as the 'hot' black body, will be heated to a temperature of approximately 50°C above that of the 'cold' black body. In the nominal mode of operation the 'cold' black body is viewed in order to provide a reference level (DC restore level) above which the response of the 'hot' black body is measured. This effectively means that the count telemetred to the ground represents the difference in count between the 'hot' and 'cold' black bodies. The temperature of the two black bodies is expected to be in the range from 5°C to 35°C for the 'cold' black body and from 55°C to 85°C for the 'hot' black body.

Space calibration mode

In this mode use is only made of one black body, the 'hot' black body. However, two options exist, the 'hot' black body can either be heated or can remain at the ambient temperature of the satellite

In the space calibration mode the reference level is provided by the radiometer looking at the space view in both options.

Either method can be used to perform a simultaneous black body calibration of the infrared and water vapour channels. ***In the situation where heating is applied to the 'hot' black body the analogue signal from the detectors is divided by two for the IR calibration and by eleven for the WV calibration, before being converted into a count!***

BBC1IR (BBC1WV)

The raw black body count for the IR (WV) channel observed during a space mode calibration.

BBSD1I (BBSD1W)

Standard deviation of the black body count for the IR (WV) channel during a space mode calibration.

BB1T (BB2T)

Temperature of the cold (hot) black body in K. The cold black body temperature is only valid for the nominal calibration mode.

BBC2IR (BBC2WV)

The raw black body count for the IR (WV) channel observed during a nominal mode calibration.

BBSD2I (BBSD2W)

Standard deviation of the black body count for the IR (WV) channel during a nominal mode calibration

CALIR (CALWV)

The absolute MIEC calibration coefficient for the IR (WV) channel which include all adjustments to account for variation of radiometer response. The calibration equation, as used in the MIEC, is for both channels:

```
Radiance = (count - SPC) * CAL
```

where SPC and CAL are the space count and calibration coefficient for the corresponding spectral channel

IRSPC (WVSPC)

Average space count for the IR (WV) spectral channels as used within the MIEC.

TIME1

This parameter gives the day of the year and slot number at which the black body calibration was performed.

TIME2

This parameter gives the day of the year and slot number at which the IR calibration coefficient became valid.

TIME3

This parameter gives the day of the year and slot number at which the WV calibration coefficient became valid.

GAINS

On board gain settings for the different spectral channels in the order IR, WV, VIS1 (VIS4), VIS2 (VIS3). The gain settings are in the range 00 - 15.

7.3 Spacecraft Operations Data

Offset	Name	Type	Length	Content
104	DEGSRA	R*8	8	Right ascension attitude south in degrees
112	DEGSDE	R*8	8	Declination attitude south in degrees
120	DEGNRA	R*8	8	Right ascension north in degrees
128	DEGNDE	R*8	8	Declination attitude north in degrees
136	FINATT	R*8	24	X, Y, Z of refined attitude
160	FARADE	R*8	16	Right ascension and declination of mean refined attitude
176	NRSLOT	I*4	4	Number of slots for refined attitude
180	SPNDUR	R*4	4	Spin duration minus nominal spin duration (μs)
184	FLECL	L*1	1	Eclipse operation

Offset	Name	Type	Length	Content
185	FLDEC	L*1	1	Decontamination
186	FLMAN	L*1	1	Manoeuvre
187	FLMODE	L*1	1	Earth/Sun mode
188	FLIR1	L*1	1	IR1 on
189	FLIR2	L*1	1	IR2 on
190	FLWV1	L*1	1	WV1 on
191	FLWV2	L*1	1	WV2 on
192	FLVIS1	L*1	1	VIS1 on
193	FLVIS2	L*1	1	VIS2 on
194	FLVIS3	L*1	1	VIS3 on
195	FLVIS4	L*1	1	VIS4 on
196			36	Spares for future use

Table 4. Interpretation data block: spacecraft operations section.

7.3.1 Description of the parameters in the Spacecraft Operations Section

This section of the Interpretation Data provides information on the satellite orbit. The co-ordinate frame used for this data is the geocentric mean equatorial system of date 1950.0 (related to the spring equinox in the year 1950) and often referred to as the $\gamma 50$ co-ordinate frame. The co-ordinate frame is an inertial frame with its origin at the centre of the Earth. The XY plane corresponds to the Earth's equatorial plane and the X-axis points in the direction of the mean vernal equinox (intersection of the Earth's equatorial plane with the ecliptic plane). The Z-axis points in the direction of celestial north (positive towards the star Polaris) and the Y-axis forms the third member of the right-handed XYZ co-ordinate frame. Figure 18 shows the co-ordinate frame $\gamma 50$.

DEGSRA

This value describes the angle between the X-axis and the vector formed by the projection of the attitude vector (spacecraft spin axis) onto the XY-plane. This value is measured during the scanning of the southern horizon of the image.

DEGSDE

This value describes the angle between the attitude vector and its projection on the XY-plane. This angle is measured during the scanning of the southern horizon of the image.

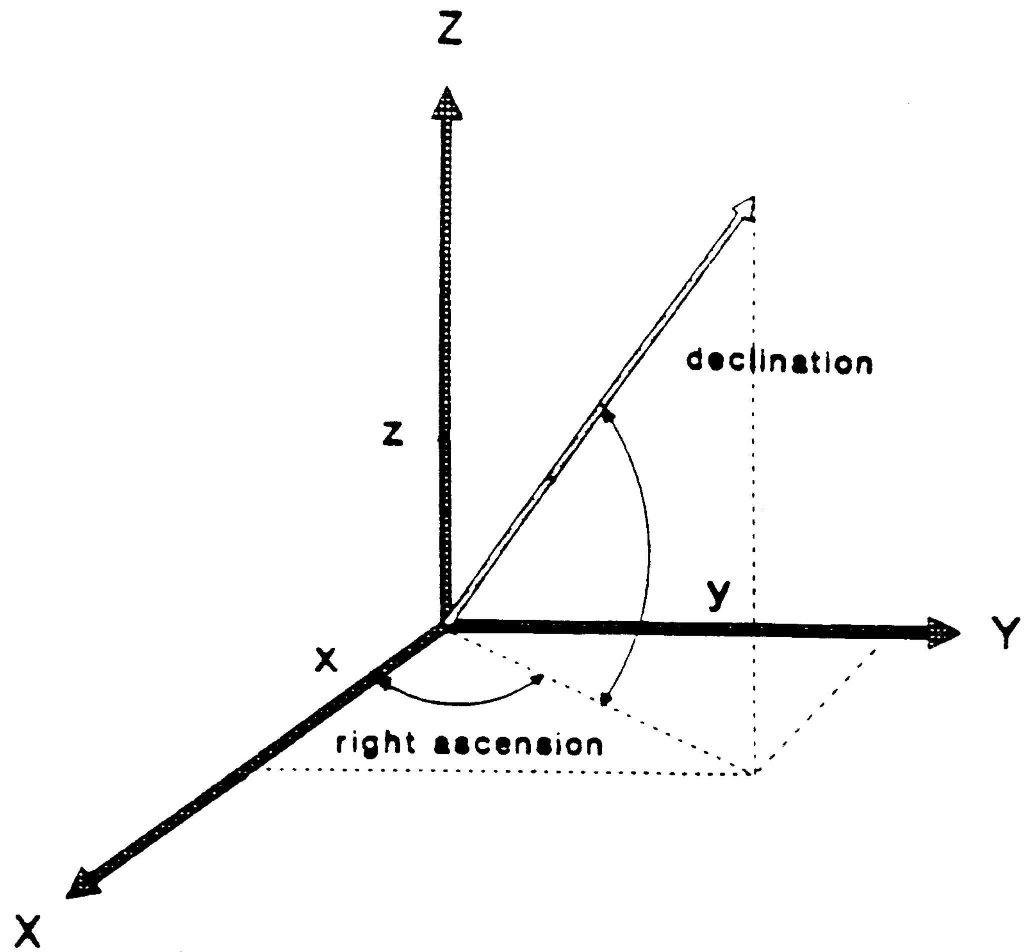

Figure 18. Inertial co-ordinate system γ50: This co-ordinate system is used to describe the satellite position in space and is related to the Spring equinox in 1950.

DEGNRA

This is the value corresponding to DEGSRA but measured during the scanning of the northern horizon of the image.

DEGNDE

This is the value corresponding to DEGSDE but measured during the scanning of the northern horizon of the image

FINATT

These are the X, Y and Z components of the attitude vector (see Figure 18) based on the refined attitude. This is a mean of the attitude vectors over the number of slots given by NRSLOT

FARADE

This is a mean of the values of the right ascension and declination over the number of slots given by NRSLOT.

NRSLOT

This is the number of slots (nominally 48) used to calculate the refined attitude i.e. the number of slots used for calculating the values of FINATT and FARADE.

SPNDUR

This time is measured during the scanning of line 1250, nominally middle of the image, and corresponding to nominal radiometer position 1350. The value transmitted is the measured spin duration in μs minus the nominal spin duration ($6.10^5 \mu s$). If the satellite rotation is faster than nominal this value will be negative.

FL***

The various operation modes are indicated by a L*1 value. If the value is set to 1 the operation mode is active during the acquisition of the image. The flags are:

FLECL - Eclipse operation.

FLDEC - Decontamination of the radiometer

FLMAN - Spacecraft manoeuvre.

FLMODE - Satellite is in Earth mode if value is 1, in Sun mode if value is 0.

FLIR1 - IR1 on.

FLIR2 - IR2 on

FLWV1 - WV1 on

FLWV2 - WV2 on.

FLVIS1 - VIS1 on

FLVIS2 - VIS2 on

FLVIS3 - VIS3 on.

FLVIS4 - VIS4 on.

7.4 Imagery Data

Offset	Name	Type	Length	Content
232	IMSTAT	L*1	16	Image status 1 Horizon analysis performed 2 Spin speed fit 3 Orbit offset vector fit 4 Pixel sampling rate fit 5 Attitude refinement iteration based on horizon results 6 Spare 7 Spare 8 Calculation of deformation vector field 9 Completion of geometrical processing 10 Completion of rectification 11 Completion of amplitude processing 12-16 Spare
248	LIMHOR	I*2	24	Southern line, 1st/last pixel Northern line, 1st/last pixel East pixel, south/north line West pixel, south/north line
272	SATDIS	R*8	8	Distance, satellite to earth centre
280	SORBOF	R*8	24	X, Y, Z components of orbit offset vector in nominal image frame when scanning southern horizon
304	NORBOF	R*8	24	X, Y, Z components of orbit offset vector in nominal image frame when scanning northern horizon
328	XDDIFM	R*4	4	Maximum deformation difference X-component within column
332	YDDIFM	R*4	4	Maximum deformation difference Y-component within column
336	XSCM	R*4	4	Maximum deformation difference X-component within lines
340	YSCM	R*4	4	Maximum deformation difference Y-component within lines
344	CONDS	L*1	4	Image conditions 1 Earth within field of view in east/west 2 Earth within field of view in south/north 3 East/west horizon limits within predicted margin 4 South/north horizon limits within predicted margin

Offset	Name	Type	Length	Content
348	LOWDYN	I*2	8	Lowest non-zero count in histogram (-1 is off) (IR1/2, VIS1/4, VIS2/3, WV1/2)
356	HIGDYN	I*2	8	Highest non-zero count in histogram (-1 is off) (IR1/2, VIS1/4, VIS2/3, WV1/2)
364	MVIS1	R*4	4	Mean value of VIS1/VIS4
368	MVIS2	R*4	4	Mean value of VIS2/VIS3
372	SNNOM	R*4	16	Signal to noise ratio in space corners (IR1/2, VIS1/4, VIS2/3, WV1/2)
388	SNNLIN	I*4	4	Number of lines used to calculate SNNOM
392	SNREP	R*4	16	S/N ratios eastern part (IR1/2, VIS1/4, VIS2/3, WV1/2)
408	SNRWP	R*4	16	S/N ratios western part (IR1/2, VIS1/4, VIS2/3, WV1/2)
424	SWMNEP	R*4	16	Mean noise count eastern part (IR1/2, VIS1/4, VIS2/3, WV1/2)
440	SWMNWP	R*4	16	Mean noise count western part (IR1/2, VIS1/4, VIS2/3, WV1/2)
456	SNMXEP	I*2	8	Maximum space count eastern part (IR1/2, VIS1/4, VIS2/3, WV1/2)
464	SNMXWP	I*2	8	Maximum space count western part (IR1/2, VIS1/4, VIS2/3, WV1/2)
472			88	Spare for future use

Table 5. Interpretation data block: imagery data section.

7.4.1 Description of parameters in the Imagery Section

These data are produced during image processing. The user is provided with information on the level of image processing performed, location of the image frame, deformation parameters and a summary of the results from image amplitude analysis processing.

IMSTAT

These data are represented by 16 L*1 values which are set to 1 if the corresponding processing was succesfully completed. The sixteen bytes are dedicated as follows:

1 Horizon analysis performed

2 Spin speed fit

3 Orbit offset vector fit

4 Pixel sampling rate fit

5 Attitude refinement iteration based on horizon results

6 Automatic landmark registration.

7 Actual image frame movement fit based on landmark results.

8 Calculation of deformation vector field.

9 Completion of geometrical processing.

10 Completion of rectification.

11 Completion of amplitude processing.

12 - 16 Spare.

LIMHOR

The group of twelve values in LIMHOR indicate the position of the Earth as seen during the scanning of the image. The positions to which the individual parameters refer are shown in Figure 19.

1 Southern line: The number of the first scan line containing Earth information.

2 First pixel: The column of the first detected pixel in the first line containing Earth information.

3 Last pixel: As above, but the column of the last detected Earth pixel in the line.

4 Northern line: The number of the last scan line containing Earth information.

5 First pixel: The column of the first detected pixel in the last line containing Earth information.

6 Last pixel: As above, but the column of the last detected Earth pixel in the line.

7 East pixel: The right most pixel (column number) in the image.

8 South line: Number of the first scan line containg the right most pixel.

9 North line: Number of the last scan line containing the right most pixel.

10 West pixel: The left most pixel (column number) in the image.

11 South line: Number of the first scan line containing the left most pixel.

12 North line: Number of the last scan line containing the left most pixel.

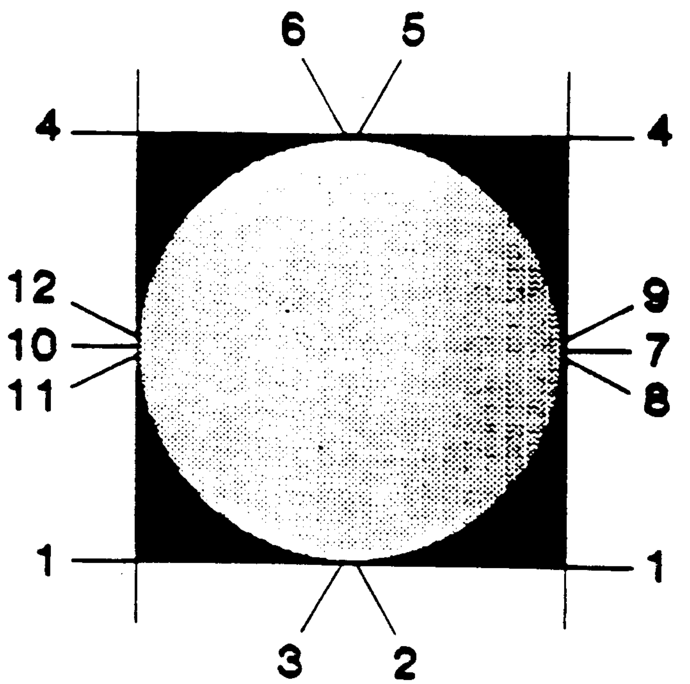

Figure 19. The position of the Earth as seen during scanning.

SATDIS

This double precision value indicates the distance of the satellite to the Earth centre in kilometres at the time of scanning the Earth's centre.

SORBOF, NORBOF

These values indicate the level of changes to the image during image geometry corrections. For the description of the image geometry the following set of co-ordinate systems is used:

- The nominal image frame (NIF) with origin at the nominal satellite position N, Xn-axis pointing towards the Earth centre, Zn-axis pointing northwards, parallel with the Earth's axis of rotation with Zn = 0 being the equatorial plane.

- The actual image frame (AIF) with origin at the momentary satellite position S, Xa-axis pointing towards the Earth, Za-axis coinciding with the attitude vector 'a' and the Earth's centre always being in the plane Ya = 0. Generally this frame is moving with each scan step of the radiometer.

Note: The subscripts 'a' and 'n' refer to AIF and NIF, respectively.

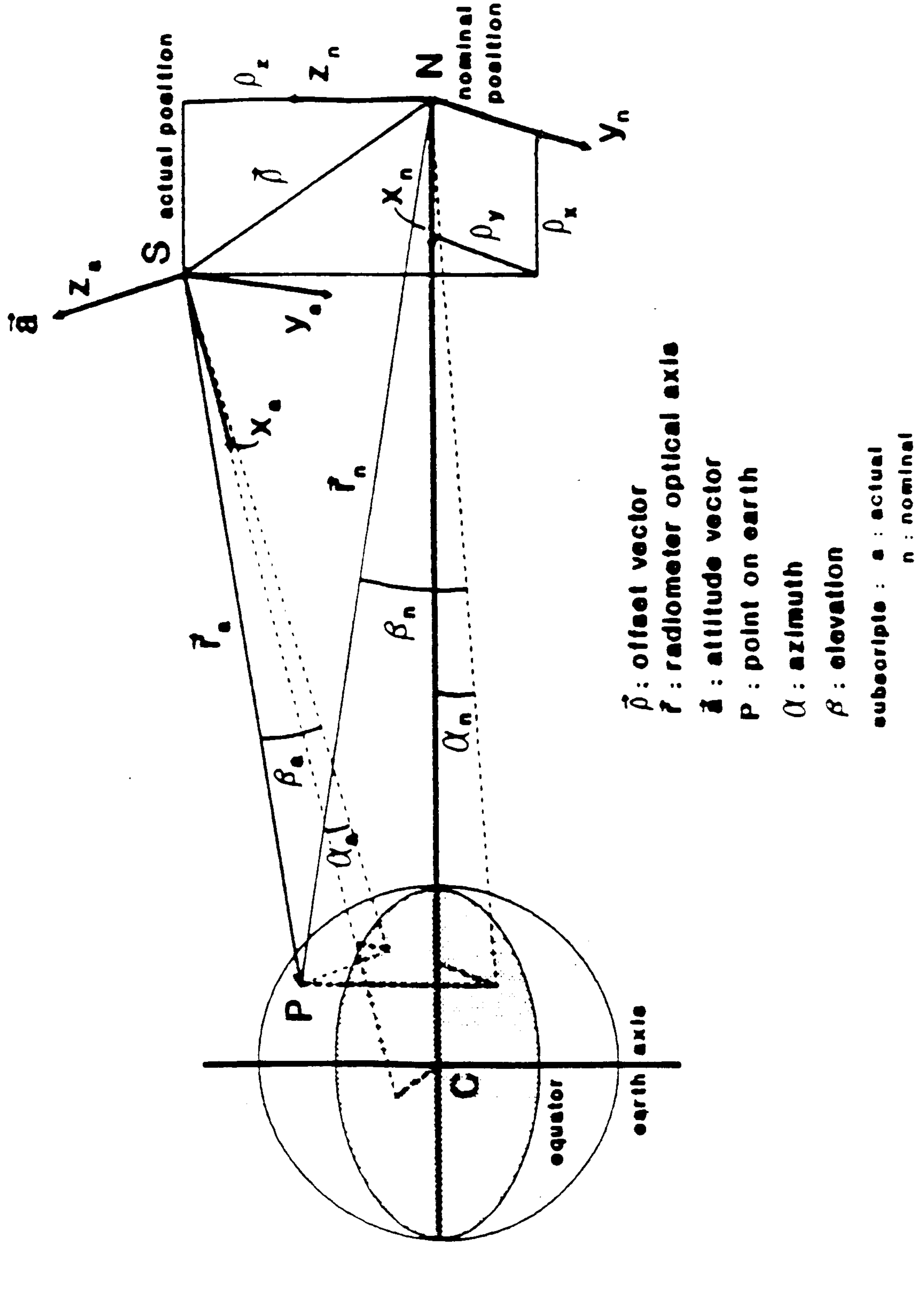

Figure 20. Co-ordinate system used to describe image deformation.: The Earth centre C is always in the planes $Ya = 0$ and $Yn = 0$

The principle idea of the image geometry model is to adjust the actual image frame at the position of the southern (northern) horizon limit scan and to express its movement (offset vector and Cardan angles) with respect to the nominal image frame as functions of the radiometer scan step. Conservation of angular momentum of the spacecraft (except during manoeuvres) is used for determining an approximate mean attitude vector as starting point for an iterative attitude refinement procedure per image.

Since infrared radiation differs significantly at all times from thermal noise coming from space, even at the polar caps of the Earth, the southern and northern horizon scan limits can easily be extracted from the infrared image. In order to get these positions accurate to a part of a pixel a parabola arc is fitted to the horizons. The radiation threshold value defining the horizon and apparent radius of the Earth are adjustable parameters in order to compensate for the thickness of the atmosphere. Figure 20 illustrates the co-ordinate systems for the description of image deformations. The values ρx, ρy and ρz correspond to the X, Y, Z values in SORBOF, NORBOF.

XDDIFM, YDDIFM, XSCM, YSCM

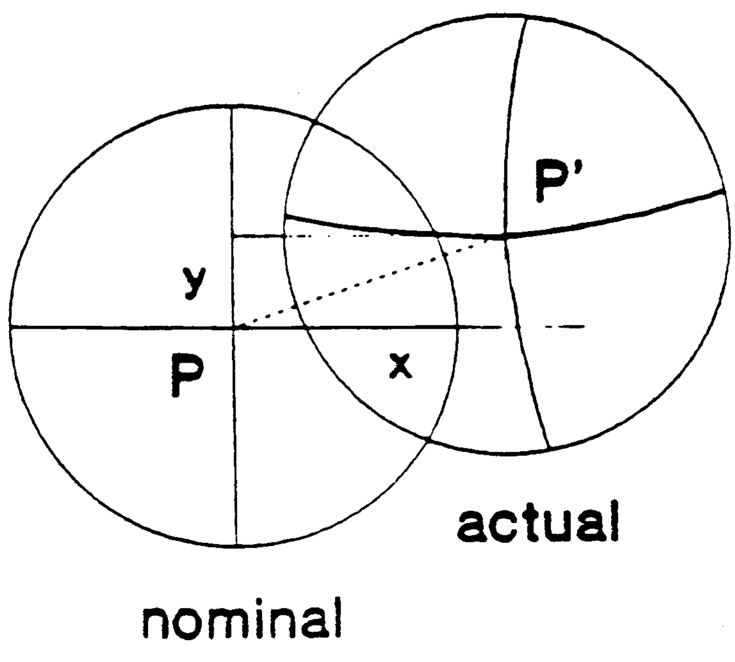

Figure 21. Maximum deformation differences (XDDIFM, YDDIFM, XSCM, YSCM).

Information on the deformation of the image is produced on a grid of 26 lines by 26 columns and the actual image is compared with the nominal reference image (see Figure 21). The maximum differences measured on the 26 x 26 grid are given in the above parameters.

CONDS

The first two logical values are set .TRUE. when the Earth was in the field of view during scanning. The first logical byte is set .TRUE. for E/W scanning, the second is set .TRUE. for N/S scanning. Bytes 3 and 4 are set .TRUE. when the scanned Earth image was within +/- 3 pixels from the predicted values (see Figure 22).

LOWDYN (HIGDYN)

LOWDYN (HIGDYN) indicates the lowest (highest) non-zero count in the histogram for IR1 or IR2, VIS1 or VIS4, VIS2 or VIS3, WV1 or WV2, in that order. If the channel is not active the value is set to -1.

MVIS1 (MVIS2)

Represents the mean value of image pixels, including space, for the VIS1/VIS4 (VIS2/VIS3) spectral channels.

The four parameters given above provide information which could be used for image enhancement in order to make use of the full dynamic range of hard copy recorders or display units.

SNNOM, SNNLIN, SNREP, SNRWP, SWMNEP, SWMNWP, SNMXEP, SNMXWP

These parameters provide information on the quality of the radiometric performance during scanning. For each channel the pixel values in space at the four corners of the image are analysed to determine the noise level.

The signal to noise ratio is calculated according to the following formula:

$$S/N = \frac{255 - O_i}{\left[(Noise)^2 + \frac{1}{12} \right]^{\frac{1}{2}}}$$

where the offset (O_i), effectively the mean count in space, and the noise, effectively the standard deviation of the count in space, are calculated from

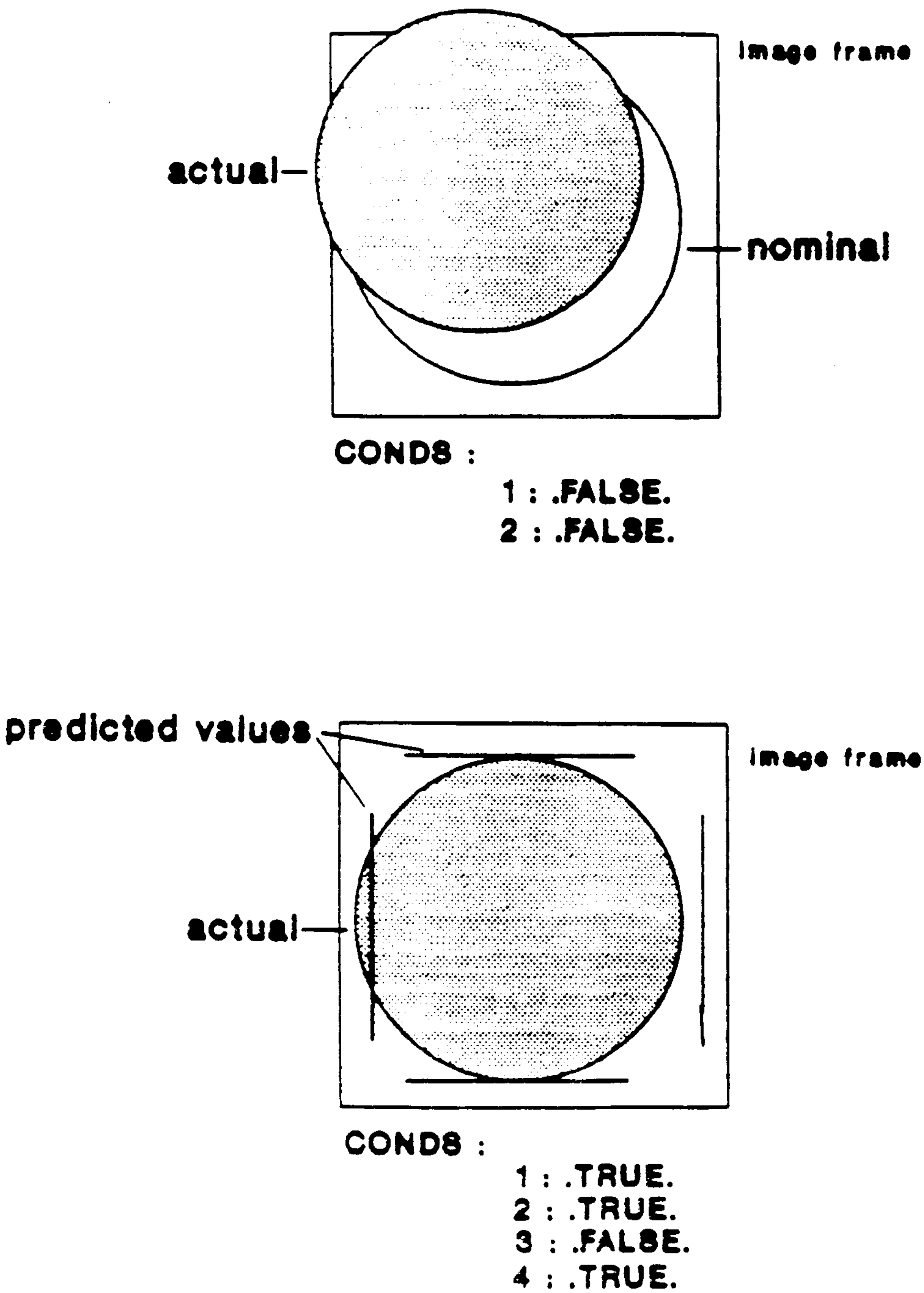

Figure 22. Image conditions (CONDS).

$$O_i = \frac{1}{N_i} \sum_{K=0}^{255} K F_i(K)$$

$$\text{Noise} = \left[\frac{1}{N_i} \sum_{K=0}^{255} K^2 F_i(K) - O_i^2 \right]^{\frac{1}{2}}$$

where K is the pixel value. F_i is the histogram of the space corners. $F_i(K)$ is the number of pixels with value K and N_i is the total number of pixels under consideration. This calculation of the signal to noise ratio includes all the quantisation noise and can be considered to be the most pessimistic S/N ratio. A more optimistic value would be given by:

$$\text{S/N (opt)} = \frac{255 - O_i}{Noise}$$

In reality the true value will be somewhere between these two values.

SNNOM: contains the signal-to-noise ratios in the space corners for IR1 or IR2. VIS1 or VIS4. VIS2 or VIS3. WV1 or WV2.

SNNLIN: contains the number of lines used to calculate SNNOM

SNREP (SNRWP): gives the S/N ratios for the eastern (western) space corners of the image for IR1 or IR2. VIS1 or VIS4. VIS2 or VIS3. WV1 or WV2.

SWMNEP (SWMNWP): gives the mean count of the eastern (western) space corners of the image for IR1 or IR2, VIS1 or VIS4. VIS2 or VIS3. WV1 or WV2.

SNMXEP (SNMXWP): gives the maximum space count of the eastern (western) space corners of the image for IR1 or IR2. VIS1 or VIS4. VIS2 or VIS3. WV1 or WV2.

7.5 Administrative messages

Offset	Name	Type	Length	Content
560	ADMMSG	ASCII	800	Administrative message

Table 6. Interpretation data block: administrative message format.

Up to 800 ASCII characters can be present in the administrative message. These are used to inform users about changes or disruptions to the [illegible] METEOSAT operations. The messages are marked with a serial number which consists of the year and month of issue and a sequence number indicating the number of the message within the month.

8.0 METEOSAT DISSEMINATION SCHEDULE

METEOSAT Dissemination Schedules list all formats disseminated from METEOSAT for reception by PDUS and SDUS (Secondary Data User Station used for receiving WEFAX formats). An example of such a schedule, which can be provided to users on request to EUMETSAT, is shown in Figure 23.

The spacecraft has two dedicated dissemination channels which can be used for both analogue and digital transmissions. Commencing with the start of operations with METEOSAT-4, on 19 June 1989, all digital dissemination formats (A, B and X-formats) will be transmitted on Channel A2 (1694.5 MHz). ***Existing users should note that this is a change to the previous policy under which digital data formats were transmitted on Channel A1 (1691.0 MHz).*** Channel A2 also includes all GOES WEFAX transmissions from CMS Lannion, some METEOSAT formats and transmissions of processed data e.g. the Cloud Top Height product and a small number of weather charts. Channel A1 is dedicated to the dissemination of METEOSAT WEFAX images. In addition, administrative messages and test patterns are transmitted at regular intervals throughout the day in WEFAX format on both channels.

In order to standardise the start time of individual formats, four minute transmission slots are used. Formats start at the nominal times of H + 02, H + 06, H + 10 etc., with the actual transmission scheduled to commence a few seconds after these nominal times. High Resolution formats may occupy between one (BI-format) and six (AV-format) of these transmission slots. The formats do not precisely occupy the total time allocated for their transmission and on Channel A2 there is no uplink in the gap between the end of one HR format transmission and the start of the next time slot. The situation is different on Channel A1, where gaps between WEFAX formats are used for the retransmission of messages from Data Collection Platforms (DCP).

HH MM	00 : UT CHA1 : CHA2	03 : UT CHA1 : CHA2	06 : UT CHA1 : CHA2	09 : UT CHA1 : CHA2	12 : UT CHA1 : CHA2	15 : UT CHA1 : CHA2	18 : UT CHA1 : CHA2	21:UT CHA1 : CHA2	HH MM
2	E3 47:	:	E3 11:MEFA 2	C7D 17:	E3 23:* *	C7D 29:MEFA 6	E3 35:	:MEFA 6	2
6	:	CTH 0:	:* *	CTH 0:	:* *	CTH 0:* *	:	CTH 0:* *	6
10	D2 48:BIW 48	D2 6:BIW 6	D2 12:BIVW12	D2 18:BIVW18	D2 24:BIVW24	D2 30:BIVW30	D2 36:BIVW36	D2 42:BIW 42	10
14	D1 48:	D1 6:	C02 12:	C02 18:	C02 24:	C02 30:	D1 36:	D1 42:	14
18	D3 48:AI 48	D3 6:AI 6	C03 12:AIVH12	C03 18:AIVH18	C03 24:AIVH24	C03 30:AIVH30	D3 36:AI 36	D3 42:AI 42	18
22	D4 48:* *	D4 6:* *	D1 12:* *	D1 18:* *	D1 24:* *	D1 30:* *	D4 36:* *	D4 42:* *	22
26	D5 48:	D5 6:	D3 12:* *	D3 18:* *	D3 24:* *	D3 30:* *	D5 36:	D5 42:	26
30	D6 48:DTOT48	D6 6:DTOT 6	D4 12:DTOT12	D4 18:DTOT18	D4 24:DTOT24	D4 30:DTOT30	D6 36:DTOT36	D6 42:DTOT42	30
34	D7 48:LY 1	D7 6:LY 7	D5 12:LY 13	D5 18:LY 19	D5 24:LY 25	D5 30:LY 31	D7 36:LY 37	D7 42:LY 43	34
38	D8 48:ETOT48	D8 6:ETOT 6	D6 12:ETOT12	D6 18:CTOT18	D6 24:CTOT24	D6 30:CTOT30	D8 36:ETOT36	D8 42:ETOT42	38
42	D2 1:BIW 1	D2 7:BIW 7	D2 13:BIV 13	D2 19:BIV 19	D2 25:BIV 25	D2 31:BIV 31	D2 37:BIV 37	D2 43:BIW 43	42
46	D9 1:LR 1	D9 7:LR 7	C02 13:LR 13	C02 19:LR 19	C02 25:LR 25	C02 31:LR 31	D9 37:LR 37	D9 43:LR 43	46
50	D1 1:AI 1	D1 7:AI 7	C03 13:AIVH13	C03 19:AIVH19	C03 25:AIVH25	C03 31:AIVH31	D1 37:AI 37	D1 43:AI 43	50
54	D3 1:* *	D3 7:* *	C3D 13:* *	C3D 19:* *	C3D 25:* *	C3D 31:* *	D3 37:* *	D3 43:* *	54
58	:	:	C2D 13:* *	C9D 19:* *	C2D 25:* *	C9D 31:* *	:	:	58

HH MM	01:UT CHA1 : CHA2	04:UT CHA1 : CHA2	07 : UT CHA1 : CHA2	10 : UT CHA1 : CHA2	13 : UT CHA1 : CHA2	16 : UT CHA1 : CHA2	19 : UT CHA1 : CHA2	22:UT CHA1 : CHA2	HH MM
2	:LXI 1	:LXI 7	C1D 13:LXI 13	:LXI 19	C1D 25:	:	:MEFA 5	:LXI 43	2
6	:	:	:	:	:	:	:* *	:	6
10	D2 2:BIW 2	D2 8:BIW 8	D2 14:BIVW14	D2 20:BIVW20	D2 26:BIVW26	D2 32:BIVW32	D2 38:BIVW38	D2 44:BIW 44	10
14	D1 2:	D1 8:	C02 14:	C02 20:	C02 26:	C02 32:	D1 38:	D1 44:	14
18	D3 2:AI 2	D3 8:AI 8	C03 14:AIVH14	C03 20:AIVH20	C03 26:AIVH26	C03 32:AIVH32	D3 38:AI 38	D3 44:AI 44	18
22	:* *	E1 8:* *	D7 14:* *	D7 20:* *	D7 26:* *	D7 32:* *	E1 38:* *	:* *	22
26	:	E2 8:	D8 14:* *	D8 20:* *	D8 26:* *	D8 32:* *	E2 38:	:	26
30	:AW 2	E3 8:AW 8	D9 14:AW 14	D9 20:AW 20	D9 26:LXIV25	D9 32:LXIV31	E3 38:LXIV37	:AW 44	30
34	:* *	E4 8:* *	D3 14:* *	D3 20:* *	D3 26:* *	D3 32:* *	E4 38:* *	:* *	34
38	:	E5 8:	:	:	:	:	E5 38:	:	38
42	D2 3:BIW 3	D2 9:BIW 9	D2 15:BIV 15	D2 21:BIV 21	D2 27:BIV 27	D2 33:BIV 33	D2 39:BIV 39	D2 45:BIW 45	42
46	D1 3:	D1 9:	C02 15:	C02 21:	C02 27:L2 25	C02 33:L2 31	D1 39:L2 37	D1 45:	46
50	D3 3:AI 3	D3 9:AI 9	C03 15:AIVH15	C03 21:AIVH21	C03 27:AIVH27	C03 33:AIVH33	D3 39:AI 39	D3 45:AI 45	50
54	:* *	E6 9:* *	:* *	:* *	:* *	:* *	E6 39:* *	:* *	54
58	:	E7 9:	D3 15:* *	D3 21:* *	D3 27:* *	D3 33:* *	E7 39:	:	58

HH MM	02:UT CHA1 : CHA2	05:UT CHA1 : CHA2	08 : UT CHA1 : CHA2	11 : UT CHA1 : CHA2	14 : UT CHA1 : CHA2	17 : UT CHA1 : CHA2	20 : UT CHA1 : CHA2	23:UT CHA1 : CHA2	HH MM
2	:MEFA 1	E8 9:	C1D 15:MEFA 3	C1D 21:	C1D 27:	C1D 33:AW 33	E8 39:AW 39	:	2
6	:* *	E9 9:	C2D 15:* *	C2D 21:	C2D 27:	C2D 33:* *	E9 39:* *	:	6
10	D2 4:BIW 4	D2 10:BIW 10	D2 16:BIVW16	D2 22:BIVW22	D2 28:BIVW28	D2 34:BIVW34	D2 40:BIW 40	D2 46:BIW 46	10
14	D1 4:	D1 10:	C02 16:	C02 22:	C02 28:	C02 34:	D1 40:	D1 46:	14
18	D3 4:AI 4	D3 10:AI 10	C03 16:AIVH16	C03 22:AIVH22	C03 28:AIVH28	C03 34:AIVH34	D3 40:AI 40	D3 46:AI 46	18
22	:* *	:* *	C3D 16:* *	C3D 22:* *	C3D 28:* *	C3D 34:* *	:* *	:* *	22
26	:	:	C4D 16:* *	:* *	C4D 28:* *	:* *	:	:	26
30	:	:	:	:	:	:	:	:	30
34	:	:	:	:	:	:	:	:	34
38	TEST 0:ADMINO	ADMINO:TEST 0	TEST 0:ADMINO	ADMINO:TEST 0	TEST 0:ADMINO	ADMINO:TEST 0	TEST 0:ADMINO	ADMINO:TEST 0	38
42	D2 5:BIW 5	D2 11:BIW 11	D2 17:BIV 17	D2 23:BIV 23	D2 29:BIV 29	D2 35:BIV 35	D2 41:BIW 41	D2 47:BIW 47	42
46	D1 5:	D1 11:	C02 17:	C02 23:AV 23	C02 29:	D1 35:	D1 41:	D1 47:	46
50	D3 5:AI 5	D3 11:AI 11	C03 17:AIVH17	C03 23:* *	C03 29:AIVH29	D3 35:AI 35	D3 41:AI 41	D3 47:AI 47	50
54	:* *	E1 11:* *	C5D 17:* *	E1 23:* *	C5D 29:* *	E1 35:* *	:* *	E1 47:* *	54
58	:	E2 11:	C4D 17:* *	E2 23:* *	C4D 29:* *	E2 35:	:	E2 47:	58

SOME FORMATS ARE SUBJECT TO SUPRESSION DUE TO SEASONAL UNDERILLUMINATION

Figure 23. Example of the METEOSAT Dissemination Schedule

8.1 *Key to the METEOSAT Dissemination Schedule*

The following notes provide information on interpreting the dissemination schedule.

SCHEDULE NUMBER

The schedule number is in the form YYMMCNN

```
YY = year of introduction.
MM = month of introduction.
C  = satellite indicator (= M).
NN = number of schedule introduced
     in this month.
```

Revised schedules are distributed to users in advance of their date of validity and are also announced by administrative message.

COLUMN HEADINGS

- CH A1 is the METEOSAT dissemination channel at 1691.0 MHz.

- CH A2 is the METEOSAT dissemination channel at 1694.5 MHz.

- HH is the hour during which the transmission commences.

ROW HEADINGS

- MM gives the minute of the hour at which the transmission will commence.

TABLE ENTRIES

These entries indicate the format type and slot number of the image disseminated. From this information the user can determine the area of the image, the spectral channels and the end time of the image to be disseminated. The slot number is simply related to to the end time of the image as follows:

```
slot 24 = image ending near to 1200 UTC.
slot 39 = image ending near to 1930 UTC.
```

i.e. the slot number is twice the end time of the image in hours (UTC)

The formats transmitted from CMS Lannion are all prefixed with an 'L'. For digital data formats the first letter indicates the area of the format and the following letters the channels to be disseminated, in accordance with the descriptions given in Section 4 of this document. Slots containing the entry 'TEST' indicate the transmission of a test pattern, those with the entry 'ADMIN' indicate the transmission of an administrative message, both in WEFAX format.

Examples

```
  AV 18 = full resolution visible image of the full
          disk as seen by METEOSAT for slot 18.

BIVW 32 = infrared plus visible plus water vapour image
          of the European and North Atlantic area for
          slot 32.

 LXI 19 = infrared image of area 'X' as seen by the GOES-E
          spacecraft for slot 19.
```

8.2 Availability of High Resolution formats

HR formats are distributed at regular intervals throughout the day in accordance with the dissemination schedule agreed with EUMETSAT. The dissemination schedule introduced on 19 June 1989 provides for an 'A' and 'B' format for each image slot to be disseminated approximately every half an hour. An 'X' format is disseminated approximately every three hours. The spectral channels disseminated are dependent on the time of day e.g. the visible channel data is only disseminated when the Earth's disk is sufficiently illuminated.

Users should note that if an image(s) is not available for dissemination, then the most recently available image in the sequence slot-1, slot-2, slot-3, will be disseminated in its place.

9.0 TECHNICAL SPECIFICATION OF A PRIMARY DATA USER STATION (PDUS)

The basic components of a PDUS are the ground station and the image handling system. The essential elements of the ground station are an antenna, low noise amplifier, down converter, receiver, demodulator and bit and frame synchronisers. The image handling system varies according to the requirements of each individual user but will require at least a computer and magnetic storage device, typically this could be either digital tape decks or Winchester disks with a minimum storage capability of 80 megabytes. Some possible options which may be required are:

- Colour image display;
- High resolution hardcopy recorder;
- Link to a larger computer system for image processing;
- Video recorder.

An example of a PDUS configuration is shown in Figure 24.

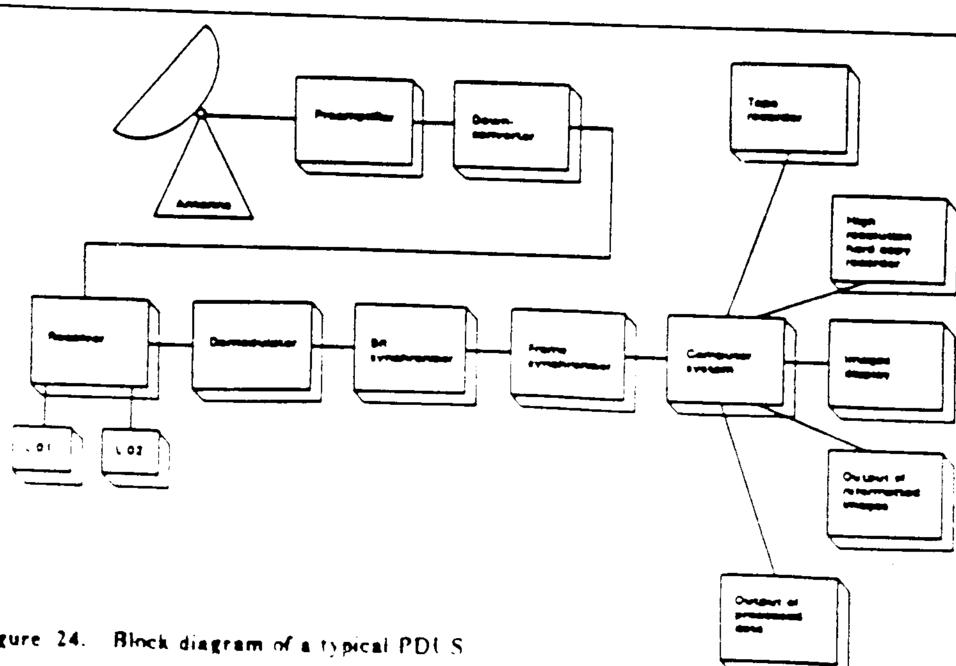

Figure 24. Block diagram of a typical PDUS

9.1 PDUS System Recommendations

The following PDUS system recommendations specifications are intended as guidelines for prospective users, however they are not complete since a PDUS will depend on user requirements and location of the station. If further advice is required the user may consult EUMETSAT.

The antenna must be suitable for operation in the 1.7 GHz band; a front-fed parabolic reflector with a diameter of 4.5 m is recommended. The receiver consists of a low noise front-end, one or more down converters and the demodulator. The selection of the input frequency of the receiver has to be made by the user but typically a frequency of 135 MHz is suitable. Since the possibility exists that HR dissemination may take place on either of the two METEOSAT dissemination channels it may be advantageous to forsee two switchable input frequencies. The recommended bandwidth of the receiver is 1 MHz and the demodulator output will be a PCM signal with a bit rate of 166.66 kbits/s.

Bit synchronisers with bit rates from 100 bits/s to 5 Mbits/s and frame synchronisers with word lengths of 8 to 24 bits and frame lengths of 4 to 256 words are commonly available; the selection of the word length will depend on the computer to be used.

The recommended G/T ratio for a PDUS is $10.5 dB.K^{-1}$; this figure can be realised with different system concepts. For instance, the use of a high quality antenna with a diameter of 4.5 m (antenna gain 33 dB) permits the use of a low cost transistor amplifier with a noise figure of approximately 100 K.

Modulation specifications are as follows:

Modulation	PCM (SP-L)/PM
Index	1.2 rad +/- 5%
Bit rate	166.66 kbits/s
RF/F	660 Hz
Min. signal to noise ratio (C/No) for receiver	-67.0 dBHz

For further information please contact

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